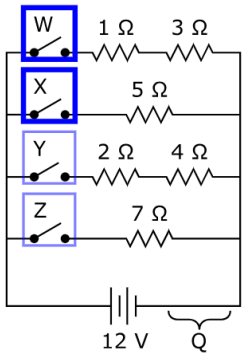
MCAS Introductory Physics Computer-based Practice Test Answer Key

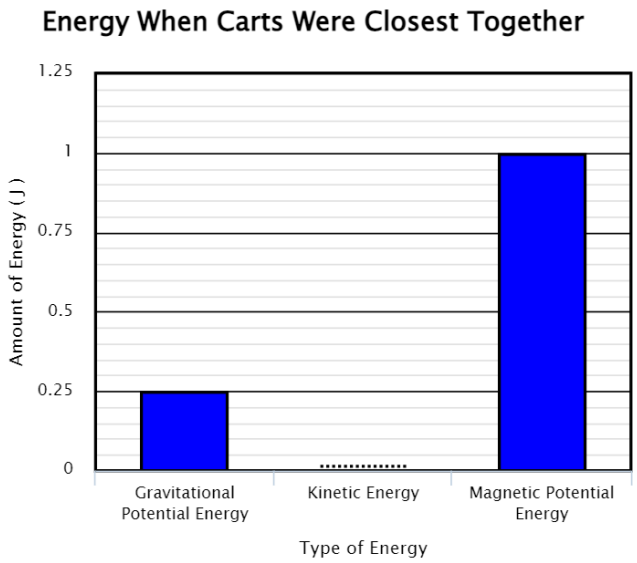
The practice test is approximately equal to what students experience (common items and matrix items) in a single session of the MCAS Introductory Physics test. Information about the test design is posted here. To allow for more familiarity with different question types, this practice test has a larger percentage of technology-enhanced questions compared to the operational MCAS test.

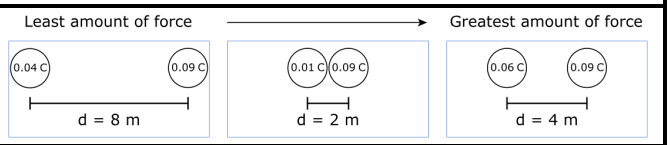
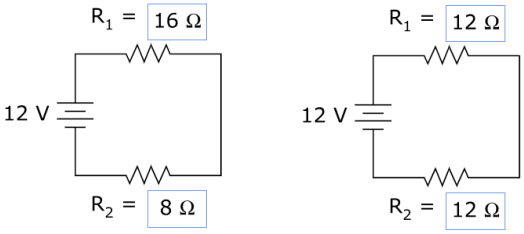
The following pages include the reporting category, standard alignment, practice (if applicable), and point value for each question on the practice test. An answer is also provided for each selected-response item. A rubric and sample student responses are included for each constructed-response item.

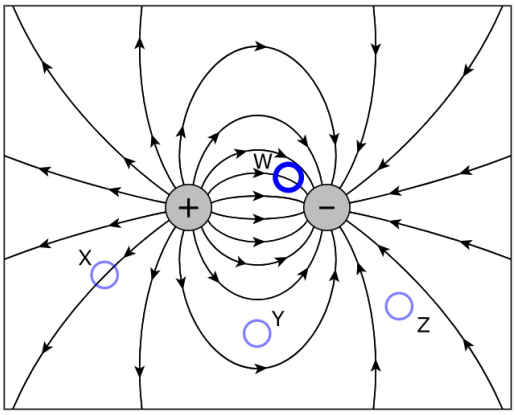
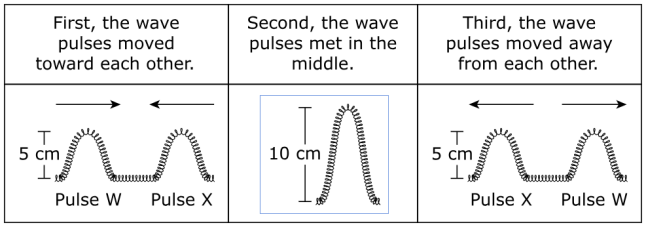
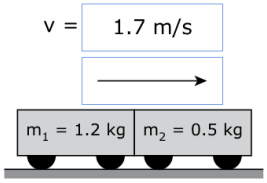
<table>
<tr><th>Item Number</th><th>Reporting Category</th><th>2016 Standard</th><th>Practice</th><th>Points</th><th>Correct Answer</th></tr>
<tr><td>1</td><td>Energy</td><td>HS-PS3-3</td><td>Evidence, Reasoning, & Modeling</td><td>1</td><td>For maximum efficiency, the device must minimize [thermal] energy while maximizing [mechanical] energy.</td></tr>
<tr><td>2</td><td>Motion, Forces, & Interactions</td><td>HS-PS2-4</td><td>Evidence, Reasoning, & Modeling</td><td>1</td><td><table><tr><th>Force Description</th><th>Only Newton's Universal Law of Gravitation</th><th>Only Coulomb's Law</th><th>Both Laws</th></tr><tr><td>The force can be repulsive.</td><td></td><td>●</td><td></td></tr><tr><td>The force can be attractive.</td><td></td><td></td><td>●</td></tr><tr><td>The force increases if the mass of both of the objects increases.</td><td>●</td><td></td><td></td></tr><tr><td>The force decreases if the distance between the objects increases.</td><td></td><td></td><td>●</td></tr></table></td></tr>
<tr><td>3</td><td>Motion, Forces, & Interactions</td><td>HS-PS2-9 (MA)</td><td>Evidence, Reasoning, & Modeling</td><td>1</td><td> 
</td></tr>
<tr><td>4</td><td>Energy</td><td>HS-PS3-1</td><td>Mathematics & Data</td><td>1</td><td><table><tr><th>Position</th><th>Gravitational Potential Energy (J)</th><th>Kinetic Energy (J)</th></tr><tr><td>A</td><td>20</td><td>0</td></tr><tr><td>B</td><td>15</td><td>5</td></tr><tr><td>C</td><td>0</td><td>20</td></tr></table></td></tr>
<tr><td>5</td><td>Energy</td><td>HS-PS3-5</td><td>Evidence, Reasoning, & Modeling</td><td>1</td><td>D</td></tr>
</table>

<table>
<tr><th>Item Number</th><th>Reporting Category</th><th>2016 Standard</th><th>Practice</th><th>Points</th><th>Correct Answer</th></tr>
<tr><td>6</td><td>Motion, Forces, & Interactions</td><td>HS-PS2-1</td><td>Mathematics & Data</td><td>2</td><td>Part A: D
Part B: If the mass of the object is increased to 6 kg and the net force remains the same, the acceleration of the object will [decrease].</td></tr>
<tr><td>7</td><td>Waves</td><td>HS-PS4-3</td><td>None</td><td>1</td><td><table><tr><th>Observation</th><th>Wave Evidence</th><th>Particle Evidence</th></tr><tr><td>A pattern of bright and dark spots is seen when light passes through two slits.</td><td>●</td><td>○</td></tr><tr><td>The higher the frequency of the light shined on a metal surface, the greater the kinetic energy of the electrons that are knocked off the surface.</td><td>○</td><td>●</td></tr></table></td></tr>
<tr><td>8</td><td>Energy</td><td>HS-PS3-4a</td><td>Mathematics & Data</td><td>1</td><td>Least heat released → Most heat released
Sample X | Sample W | Sample Y</td></tr>
<tr><td>9</td><td>Motion, Forces, & Interactions</td><td>HS-PS2-10 (MA)</td><td>Evidence, Reasoning, & Modeling</td><td>1</td><td>A</td></tr>
<tr><td>10</td><td>Energy</td><td>HS-PS1-8</td><td>Evidence, Reasoning, & Modeling</td><td>1</td><td>When an atomic nucleus splits into fragments, a nuclear [fission] process has occurred. The fragments initially have [kinetic] energy, which is transferred to the surrounding medium as [thermal energy].</td></tr>
<tr><td>11</td><td>Waves</td><td>HS-PS4-1</td><td>Mathematics & Data</td><td>1</td><td>D</td></tr>
<tr><td>12</td><td>Motion, Forces, & Interactions</td><td>HS-PS2-3</td><td>Evidence, Reasoning, & Modeling</td><td>1</td><td><table><tr><th>Device</th><th>Mass of Egg (kg)</th><th>Velocity of Egg before Impact (m/s)</th><th>Time to Stop Egg (s)</th><th>Result</th></tr><tr><td>1</td><td>0.05</td><td>14</td><td>0.01</td><td>egg broke</td></tr><tr><td>2</td><td>0.05</td><td>14</td><td>0.05</td><td>egg did not break</td></tr><tr><td>3</td><td>0.05</td><td>14</td><td>0.10</td><td>egg did not break</td></tr></table></td></tr>
<tr><td>13</td><td>Waves</td><td>HS-PS4-1</td><td>Evidence, Reasoning, & Modeling</td><td>1</td><td>B</td></tr>
</table>

Module: Students read about a scientific scenario or phenomenon and then answered three 1-point questions, one 2-point question, and one constructed response question worth 3 points. Some modules will have five 1-point questions and one 3-point constructed response question instead.

Item Number	Reporting Category	2016 Standard	Practice	Points	Correct Answer
14	Motion, Forces, & Interactions	HS-PS2-2	Mathematics & Data	1	B
15	Motion, Forces, & Interactions	HS-PS2-10 (MA)	Evidence, Reasoning, & Modeling	1	C
16	Energy	HS-PS3-1	Evidence, Reasoning, & Modeling	1	
17	Motion, Forces, & Interactions	HS-PS2-2	Mathematics & Data	2	Part A: During the collision in trial 1, momentum was [conserved] and kinetic energy was [not conserved]. During the collision in trial 2, momentum was [conserved] and kinetic energy was [conserved]. Part B: D, E
18	Motion, Forces, & Interactions	HS-PS2-1	Mathematics & Data	3	See scoring guide and sample student responses below. (Maximum of 3 points)

Item Number	Reporting Category	2016 Standard	Practice	Points	Correct Answer
19	Motion, Forces, & Interactions	HS-PS2-4	Mathematics & Data	1	
20	Motion, Forces, & Interactions	HS-PS2-9 (MA)	Mathematics & Data	1	One of the following: 
21	Energy	HS-PS3-2	None	1	A
22	Waves	HS-PS4-1	Mathematics & Data	2	Part A: B Part B: Sound waves travel through air at a speed that is [slower than] the speed at which they travel through brick. The 400 Hz sound wave traveling through air has a [shorter] wavelength than the 400 Hz sound wave traveling through brick.
23	Energy	HS-PS3-1	Mathematics & Data	2	Just before both objects hit the ground, object W's kinetic energy was [greater than] object X's kinetic energy. Just before both objects hit the ground, object W's velocity was [equal to] object X's velocity.

Item Number	Reporting Category	2016 Standard	Practice	Points	Correct Answer
24	Energy	HS-PS3-5	Evidence, Reasoning, & Modeling	1	
25	Motion, Forces, & Interactions	HS-PS2-10 (MA)	Evidence, Reasoning, & Modeling	1	B
26	Waves	HS-PS4-5	Evidence, Reasoning, & Modeling	1	
27	Motion, Forces, & Interactions	HS-PS2-2	Mathematics & Data	1	
28	Energy	HS-PS3-4a	Mathematics & Data	4	See scoring guide and sample student responses below. (Maximum of 4 points)
29	Motion, Forces, & Interactions	HS-PS2-9 (MA)	Evidence, Reasoning, & Modeling	4	See scoring guide and sample student responses below. (Maximum of 4 points)
30	Motion, Forces, & Interactions	HS-PS2-10 (MA)	Evidence, Reasoning, & Modeling	4	See scoring guide and sample student responses below. (Maximum of 4 points)

Question 18: Scoring Guide

Score	Description
3	The response demonstrates a thorough understanding of how to analyze the forces that act on objects during collisions and how these forces affect the motion of each object. The response correctly compares the forces between carts X and Y and explains the answer. The response also correctly calculates the acceleration of cart X and the force on cart X during the collision.
2	The response demonstrates a partial understanding of how to analyze the forces that act on objects during collisions and how these forces affect the motion of each object.
1	The response demonstrates a minimal understanding of how to analyze the forces that act on objects during collisions and how these forces affect the motion of each object.
0	The response is incorrect or contains some correct work that is irrelevant to the skill or concept being measured.

Question 18: Sample Student Responses

Score	Part	Student Response
3	A	They are the same because of Newton's 3rd law: for every action there is an equal and opposite reaction.
	B	$a = \frac{\Delta v}{\Delta t}$ $a = -\frac{.4}{.1}$ $a = -4 \cdot \frac{m}{s^2}$
	C	$f = ma$ $f = .5 \times (-4)$ $f = -2newtons$
2	A	X and Y exerted the forces of the same magnitude on each other as according to Newton's 3rd law which states that for every action there is an equal and opposite reaction.
	B	$vf = vi + a\Delta t$ $(vf - vi) \div t = a$ $(0.2 - 0.6) \div 0.1 = a$ $a = -4 \cdot \frac{m}{s^2}$
	C	$f = ma$ $f = 0.5 \times (-4)$ $f = -8N$

1	A	The magnitude of the forces that cart X and cart Y exerted on each other during the collision were different because cart Y was not moving but cart X was so Cart X exerted more force.
	B	$a = \frac{v}{t}$ $a = \frac{.2-.6}{.1}$ $a = -\frac{.4}{.1}$ $a = -4 \cdot \frac{m}{s^2}$
	C	$F = ma$ $F = 1 \times (-4)$ $F = -4$ N
0	A	Since Cart Y is .5 kilograms bigger than Cart X the force exerted was greater on cart X from Y than from X on Y.
	B	$A = \frac{V}{T}$ V = 6 meters per second $T = .5$ seconds $A = \frac{6}{0.5}$ A = 12 meters per second squared
	C	The Magnitude exerted on cart Y by X is .5 newtons

Question 28: Scoring Guide

Score	Description
4	The response demonstrates a thorough understanding of the relationship between thermal energy, temperature change, mass, and specific heat. The response correctly calculates the thermal energy absorbed by the water. The response clearly describes what happens to the temperature of the water as it boils and explains the answer. The response correctly compares the amount of thermal energy absorbed by the water in the first and second experiments and clearly explains the answer. The response also clearly describes how using a material with a greater specific heat will affect the time it takes to heat the block.
3	The response demonstrates a general understanding of the relationship between thermal energy, temperature change, mass, and specific heat.
2	The response demonstrates a limited understanding of the relationship between thermal energy, temperature change, mass, and specific heat.
1	The response demonstrates a minimal understanding of the relationship between thermal energy, temperature change, mass, and specific heat.
0	The response is incorrect or contains some correct work that is irrelevant to the skill or concept being measured.

Question 28: Sample Student Responses

Score	Part	Student Response
4	A	$m = 200\ g$ $\Delta t = 80 - 20 = 60°C$ $c = 4.18\ J/g \cdot °C$ $Q = ?$ $Q = mc\Delta T$ $Q = 200(60)4.18$ $Q = 50160J$ The thermal energy absorbed by the water is 50160J. I used the heat equation to find this answer.
	B	As the water starts to boil, or change from a liquid to a gas state, it under goes a phase change. Instead of heat increasing the temperature of the water as it does when matter is not in a phase change, the heat is used to change the state of the water and therefore is not used to increase the water's temperature. For this reason, the water does not increase in temperature as it boils.
	C	in this experiment, the water absorbs the same amount of thermal energy as in part (a). This is because the change in temperature (ΔT), specific heat (c) and mass (m) of the water do not change, so the solution of the heat equation, $Q = mc\Delta T$, will be the same as in part (a).
	D	If the block in experiment 2 were to have a higher specific heat, it will take more time to heat the block. This is because specific heat is the amount of heat it takes per gram to raise one degree Celcius, so if the specific heat is higher, it takes more energy to heat a certain amount, therefore taking more time as the mass of the block is changing.

3	A	Q = heat Q = mass x specific heat x ΔT 200 g × 4.18 J/g·°C × 60°C 80°C - 20°C $T_F - T_I$ 50,160 J
	B	The temperature increases after a person boils it because the molecules move rapidly and heat is traversed.
	C	Q = mcΔT = 200g .45 J/g·°C 80°C - 20°C 5400 J for the iron block. 50,160 J for the water.
	D	The more specific heat it has the longer it will take to heat up because more heat energy is needed.
2	A	given: m = 200 g c = 4.18 J/g·°C ΔT = 60°C find: thermal energy formula: Q = mcΔT math: (200)(4.18)(60) answer: 50,160 J.
	B	When the water starts to boil, the temperature will rise and get hotter and the adoms will start moving faster.
	C	m = 200 g c = .45 J/g·°C ΔT = 60°C thermal energy Q = mcΔT (200)(.45)(60) 5,400 J The thermal Energy in part A was bigger than it was in part C because in part A, the specific heat was 4.18 J/g·°C and part C was .45 J/g·°C.
	D	The specific heat will affect the amount of time it takes to heat up the block because if it has a greater specific heat, then it would take alot longer to heatup the block when you try and boil it.
1	A	The thermal energy absorbed by the water would be 50160. I know because I multiplied the mass (200) by the specific heat (4.18) by the change in temperature (60) and it was 50160.
	B	When the water boils the temperature gets much warmer.
	C	The amount of thermal energy absorbed by the water was less than it was in part A. Because the Iron has a smaller heat capacity it made the thermal energy absorbed less.
	D	If you repeated the experiment with a block with a greater specific heat, it will take far less time to heat the block.
0	A	The total thermal energy absorbed by the water is 1.19 J/g·C°
	B	The temperature of the water rises as the more the water boils.
	C	The total thermal energy absorbed by the water is 11.1 J/g·C°. In part a, the total thermal energy absorbed by the water is 1.19 J/g·C°. Theres a big difference from part A to Part C.
	D	repeating the second experiment will take faster because once heat hits the block it will heat up automatically

Question 29: Scoring Guide

Score	Description
4	The response demonstrates a thorough understanding of current and resistance in series and parallel circuits. The response correctly compares the brightness of bulbs X and Y when the switch is open, and clearly describes what will happen to bulbs X and Y when the switch is closed. The response also clearly describes one change that occurs when another bulb is added at point Z and correctly calculates the current in this circuit.
3	The response demonstrates a general understanding of current and resistance in series and parallel circuits.
2	The response demonstrates a limited understanding of current and resistance in series and parallel circuits.
1	The response demonstrates a minimal understanding of current and resistance in series and parallel circuits.
0	The response is incorrect or contains some correct work that is irrelevant to the skill or concept being measured.

Question 29: Sample Student Responses

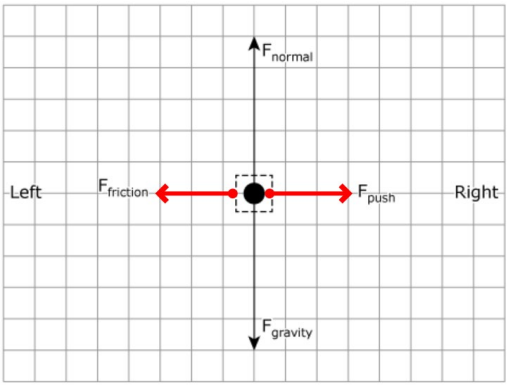
Score	Part	Student Response
4	A	When the switch is open bulb X and bulb Y both have the same brightness. They are each half as bright as they would be if there was only one bulb.
	B	When the switch is closed both bulbs do not have the same brightness anymore. Bulb X will become brighter and bulb Y will turn off.
	C	One way this circuit functions differently is when an extra bulb is added. each bulb is less bright. Since there are now 3 bulbs, each bulb becomes 1/3 as bright as it would be if there was only one bulb.
	D	When the switch is open, this circuit has a current of 2 Amps. To get my answer I divided the 30 V from the battery by the total of 15 Ω of resistance to get 2 A of current. $I = \frac{V}{R}$ $I = \frac{30V}{15\Omega}$ I = 2 A

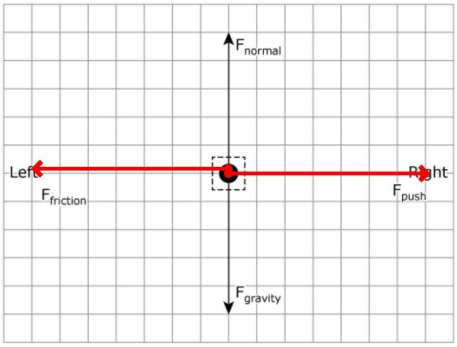
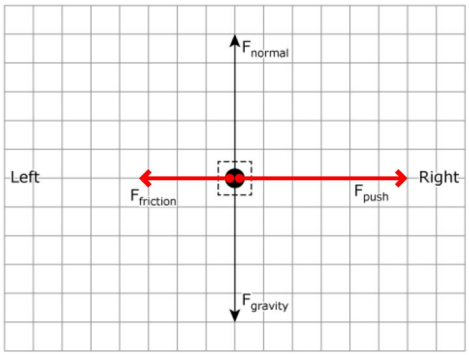
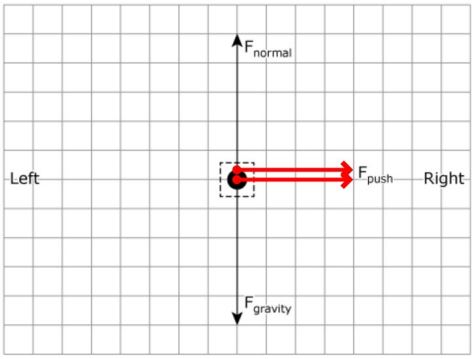
3	A	When the switch is open Bulbs X & Y are both equally bright.
	B	When the switch is closed, Bulb X gets brighter & bulb Y turns off completely.
	C	When Bulb Z was added Bulb X & Y both got dimmer, & and equal amount of current went to Bulb Z, making all 3 lightbulbs have the same brightness.
	D	Bulb X: $V = 30$ V $\quad R = 5\Omega \quad I = ?$ $I = \frac{V}{R} = \frac{30}{5} = 6$ A Bulb Y: $V = 30$ V $\quad R = 5\Omega \quad I = ?$ $I = \frac{V}{R} = \frac{30}{5} = 6$ A Bulb Z: $V = 30$ V $\quad R = 5\Omega \quad I = ?$ $I = \frac{V}{R} = \frac{30}{5} = 6$ A
2	A	Bulb X is brighter than bulb Y when the switch is open.
	B	When the switch is closed, both bulbs X and Y are unaffected.
	C	The total resistance is now 15 Ω, and is no longer 10 Ω.
	D	$V = IR$ $30V = I\,(15\Omega)$ $\frac{30V}{15} = \frac{I(15\Omega)}{15}$ $2 = I$ Current is 2 amps
1	A	Bulb X and bulb Y would not be lit up because the switch is open, which doesn't allow electrical current to flow.
	B	When the switch is closed both bulbs X and Y would light up because electric current is flowing through the circuit.
	C	The circuit functions differently from when the switch was open because now the battery provides voltage for three bulbs.
	D	I = ? V = 30 V R = 15 Ω $I = \frac{V}{R}$ I = $\frac{30}{15}$ I = 2 Amps
0	A	Bulb X will be brighter than Bulb Y when the switch is open
	B	Current will flow through both bulbs X and Y when the switch is closed
	C	The current in the circit flows through a lightbulb more quickly. The circit uses up its energy quickly
	D	Bulbs X, Y and Z

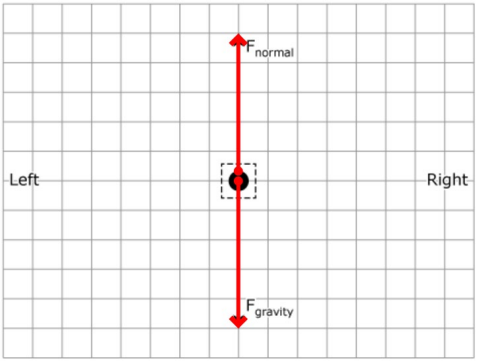
Question 30: Scoring Guide

Score	Description
4	The response demonstrates a thorough understanding of using free-body force diagrams. The response correctly shows the horizontal forces acting on a bookcase by adding arrows and force labels to a free-body force diagram. The response correctly identifies a way to change a floor that would increase the amount of force required to move the bookshelf and clearly explains the reasoning. The response also correctly identifies a different way to change the bookcase that would increase the amount of force required to move the bookshelf and clearly explains the reasoning.
3	The response demonstrates a general understanding of using free-body force diagrams.
2	The response demonstrates a limited understanding of using free-body force diagrams.
1	The response demonstrates a minimal understanding of using free-body force diagrams.
0	The response is incorrect or contains some correct work that is irrelevant to the skill or concept being measured.

Question 30: Sample Student Responses

Score	Part	Student Response
4	A	
	B	A change to the floor that would affect the amount of force required to move the bookcase at a constant speed would be if the floor was rougher, like if sandpaper was added to it. A rough floor would increase the amount of friction acting on the bookcase so it would take a bigger force to push the bookcase.
	C	A different change to the bookcase that would affect the amount of force required to move the bookcase at a constant speed would be if the bookcase had more mass added to it, like if books were put on it. More mass would take a bigger force to push the bookcase.

3	A	
	B	One change would be to raise part of the floor so that it was on an angle. You'd have to push the bookcase harder if you were pushing it up an angled floor.
	C	A different change would be to add more books to the bookcase or to remove books from the bookcase. This would change the mass of the bookcase.
2	A	
	B	You could polish the floor so it would be smoother. If you did that then it would not take as much force to push it.
	C	You could remove the friction force.
1	A	
	B	You could make the amounts of push force uneven.
	C	You could change the mass of the bookcase.

0	A	
	B	Add more gravity. The bookcase would be pulled toward the floor if there was more gravity.
	C	Add more normal force. The bookcase would be pushed off the floor if there was more normal force.