6th Force & Motion
Summative Assessment
Scoring Rubrics

1. During a youth track event, a runner travels a distance of 100 meters in a time of 20 seconds.

   a. What is the runner's average speed?

   b. Name a force that could change the speed of the runner and explain how this force would affect the speed of the runner.

Rubric: Question #1

This item measures the student's ability to quantify the average speed of a moving object and identify an unbalanced force that can change the speed of an object.

Criterion for a Complete Response (Part A):

1. The student calculates the average speed to be 5 m/s and shows appropriate work (i.e., he/she divides 100 meters by 20 seconds or uses a ratio table)

Code	Response
	Complete Response
10	Meets the criterion for a complete response.
19	Any other completely correct response.
	Incorrect Response
70	Student correctly states that the average speed is 5 m/s but omits work.
71	Student shows work but incorrectly quantifies the average speed.
72	Student correctly states that the average speed is 5 m/s but omits appropriate units.
76	Repeats the stem of the question.
79	Any other incorrect response.
	Non-Response
90	Crossed out/erased, illegible, or impossible to interpret.
99	Blank.

Criterion for a Complete Response (Part B):

1. The student names an acceptable force (such as air resistance or "traction" friction) that would change the speed of the runner and includes a description of how the force would change the runner's speed (i.e., the runner's speed would slow down because of the force of air resistance or "traction" friction makes the runner go faster).

Note: The student may mention a force that affects the runner, such as the force of gravity, but it does not affect the runner's speed. The answer must be a force that does influence the speed of the runner. It would be very difficult to describe how the force of gravity could affect the runner's speed. The "effect" on the speed may be detailed, but the minimally

desired outcome is a statement that tells whether the speed will decrease or increase due to the effects of this force.

Common Acceptable Responses:

Force of Friction	provides traction for the runner; it is responsible for creating the runner's motion.
Force of Air Resistance	an opposing force; it will slow the runner down.

Common Unacceptable Responses:

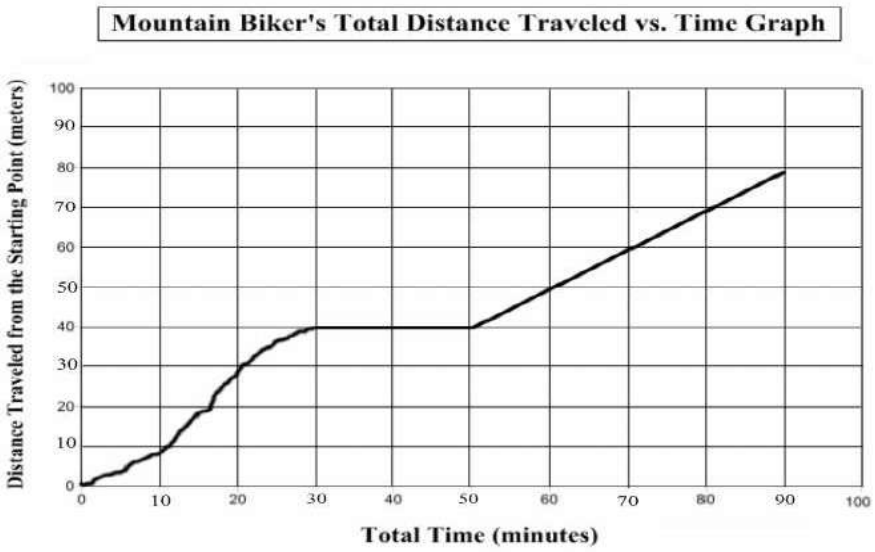
Force of Gravity	pulls the runner downward; will slow the runner.
Mass	increases the weight; will slow the runner.

Code	Response
	Complete Response
10	Meets the criterion for a complete response.
19	Any other completely correct response.
	Incorrect Response
70	Student names an acceptable force but omits explanation as to how this force will affect the runner's speed.
71	Student names an unacceptable force with little to no explanation as to how this force will affect the runner's speed.
76	Repeats the stem of the question.
79	Any other incorrect response.
	Non-Response
90	Crossed out/erased, illegible, or impossible to interpret.
99	Blank.

2. A mountain biker is in a race and his team tracks his motion on a distance vs. time graph (illustrated below). During the race, the biker has a flat tire and must stop to change it before finishing the race.

   a. How long did it take the mountain biker to change the flat tire? Describe how you get your answer using information from the graph.

   b. For how long was the mountain biker moving at constant speed? Describe how you get your answer using information from the graph.



Rubric: Question #2

This item measures the student's ability to interpret a distance vs. time graph in terms of the motion of an object.

Criteria for a Complete Response (Part A):

1. The student states that it takes the mountain biker 20 minutes to fix the flat tire.
2. The student explains that the flat line on the graph represents no motion (or speed) and that the rider must have stopped between the 30-minute mark and the 50-minute mark to fix the flat tire.

Code	Response
	Complete Response
10	Meets the criterion for a complete response.
19	Any other completely correct response.
	Incorrect Response
70	Student correctly states that the time is 20 minutes but explanation is flawed.
71	Student correctly states that the time is 20 minutes but omits explanation.
72	Student incorrectly states the time but offers some explanation as to how he/she arrived at the answer.
76	Repeats the stem of the question.
79	Any other incorrect response.
	Non-Response
90	Crossed out/erased, illegible, or impossible to interpret
99	Blank.

Criterion for a Complete Response (Part B):

1. The student states that the mountain biker is traveling at constant speed for 40 minutes. He/she explains that, between the 50-minute mark and the 90-minute mark, the line on the graph is straight which represents constant speed, so the time spent traveling at constant speed was 40 minutes.

Note: The student may mention the fact that the "stopped" portion is also a "constant" speed, so the answer may be presented as 60 minutes. This is also a correct answer, though not very common, and is an acceptable alternative to the aforementioned criterion with adequate explanation by the student.

Code	Response
	Complete Response
10	Meets the criterion for a complete response.
19	Any other completely correct response.
	Incorrect Response
70	Student states the time is 40 minutes but offers an explanation that states only that the line on the graph is straight.
71	Student states the time is 40 minutes but offers an unacceptable explanation of the answer.
72	Student incorrectly quantifies the time for constant speed and offers little to no explanation of the answer.
76	Repeats the stem of the question.
79	Any other incorrect response.
	Non-Response
90	Crossed out/erased, illegible, or impossible to interpret.
99	Blank.

3. A swimmer is competing in a 300-meter race. Her coach monitored her progress during the race and plotted her total distances traveled at the end of each one-minute time interval on a bar graph.

   Use the graph to answer the following questions.

   a. During which minute is the swimmer moving the slowest? Describe how you get your answer using information from the graph.

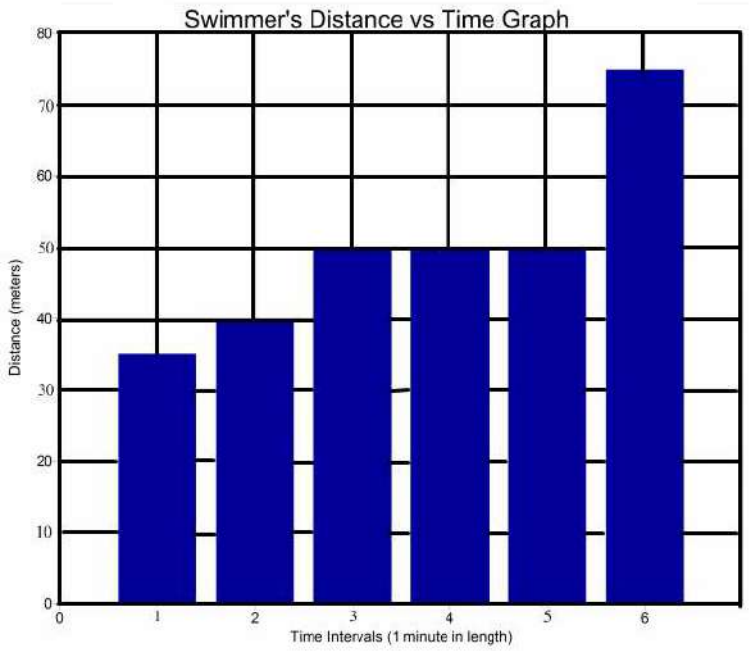
   b. During which time intervals did the swimmer's speed change? Describe how you get your answer using information from the graph.

   0 to 1 minute **1 to 2 minute** **2 to 3 minute**

   3 to 4 minute **4 to 5 minute** **5 to 6 minute**

   c. During which time intervals were the forces on the swimmer balanced? Describe how you get your answer using information from the graph.

   0 to 1 minute **1 to 2 minute** **2 to 3 minute**
   3 to 4 minute **4 to 5 minute** **5 to 6 minute**



Rubric: Question #3

This item measures the student's ability to interpret a bar graph in terms of the motion of an object.

Criteria for a Complete Response (Part A):

1. The student identifies that during the 1st minute (or first time interval) the swimmer is moving with the slowest speed.
2. The student explains that the bar in this time segment is the shortest and that represents the smallest distance traveled in the time period of one minute.

Code	Response
	Complete Response
10	Meets the criteria for a complete response.
19	Any other completely correct response.
	Incorrect Response
70	Student correctly states that the 1st minute represents the slowest speed but the explanation is flawed.
71	Student correctly states that the 1st minute represents the slowest speed but omits explanation.
72	Student incorrectly identifies the correct time segment but offers a partial explanation.
76	Repeats the stem of the question.
79	Any other incorrect response.
	Non-Response
90	Crossed out/erased, illegible, or impossible to interpret.
99	Blank.

Criteria for a Complete Response (Part B):

1. The student identifies that the swimmer's speed changed between the 1st and 2nd minutes, 2nd and 3rd minutes, and between the 5th and 6th minutes.
2. The student explains that the heights of the bars on the graph change during these time segments, meaning that the speed also changes.

Note: The student may provide numerical evidence from the graph in the explanation of his/her answer. Numerical support is helpful in the explanation but is not necessary for a complete response.

The student may also include the fact that the speed changed between the start of the race (time = 0) and the 1st one minute time interval. This is correct and may be included in the response, but it is not necessary for a complete response.

Code	Response
	Complete Response
20	Meets the criteria for a complete response.
29	Any other completely correct response.
	Partially Correct Response
10	Student meets criterion #1 only.
11	Student only identifies one correct time segment, with adequate explanation.
19	Any other partially correct response.
	Incorrect Response
70	Student identifies incorrect time segment(s) with explanation.
71	Student identifies incorrect time segment(s) and omits explanation.
76	Repeats the stem of the question.
79	Any other incorrect response.
	Non-Response
90	Crossed out/erased, illegible, or impossible to interpret.
99	Blank.

Criteria for a Complete Response (Part C):

1. The student identifies that the swimmer experiences balanced forces between the 3rd and 4th time segments and between the 4th and 5th time segments.
2. The student explains that, during these time segments, the speed did not change and that the forces must be balanced so that the speed does not change.

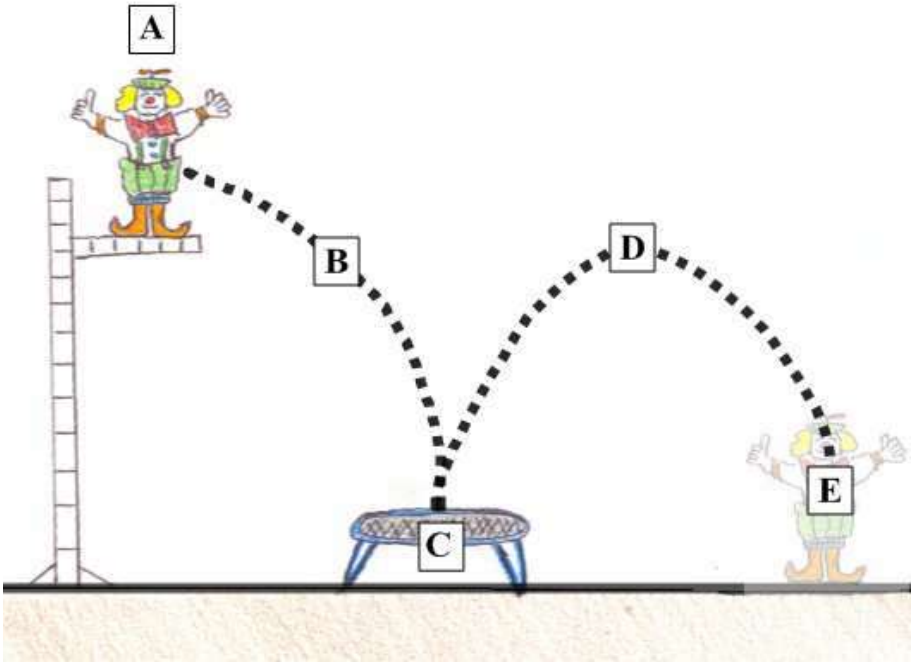
Note: The student may provide numerical evidence from the graph in the explanation of his/her answer. Numerical support may be helpful in the explanation, but it is not necessary for a complete response.

Code	Response
	Complete Response
20	Meets the criteria for a complete response.
29	Any other completely correct response.
	Partially Correct Response
10	Student meets criterion #1 only.
11	Student only identifies one correct time segments, with adequate explanation.
	Incorrect Response
70	Student identifies an incorrect time segments with explanation.
71	Student identifies an incorrect time segment and omits explanation.
76	Repeats the stem of the question.
79	Any other incorrect response.
	Non-Response
90	Crossed out/erased, illegible, or impossible to interpret.
99	Blank.

4. During a circus act, a clown completes a stunt. He jumps from the top of a tall platform and lands on a large trampoline, which then launches him back up into the air where he eventually lands on the ground.

   a. At which identified locations (**A, B, C, D, or E**) does the force of **gravity** act on the circus clown? Explain why you chose that location (or locations).

   b. Name two <u>other</u> forces that act on the clown during the stunt and identify the location (or locations) where these forces act.



Rubric: Question #4

This item measures the student's understanding of the force of gravity and how it affects the motion of an object. It also measures the student's ability to identify other forces acting on an object and when these forces are balanced.

Criteria for a Complete Response (Part A):

1. The student identifies that at all locations (A, B, C, D, and E) the force of gravity is acting on the circus clown.
2. The student provides an explanation that includes the idea that gravity is <u>always</u> acting on objects. The explanation may also include additional information such as the fact that gravity always acts downward and that its effects can be cancelled out by a support force.

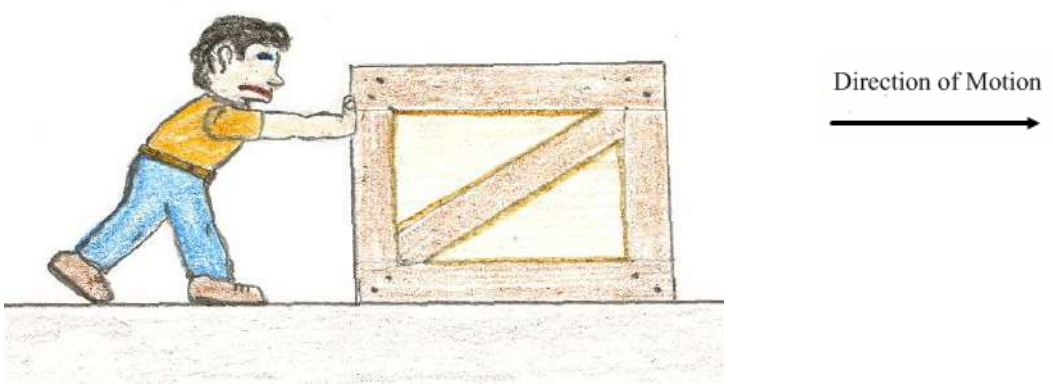
Code	Response
	Complete Response
10	Meets the criterion for a complete response.
19	Any other completely correct response.
	Incorrect Response
70	Student identifies locations B and C only; the explanation emphasizes the fact that the clown is falling downward.
71	Student identifies locations B, C, and D only; the explanation emphasizes the fact that the clown is moving at those locations.
72	Student identifies location B only; the explanation emphasizes the fact that the clown is falling downwards.
76	Repeats the stem of the question.
79	Any other incorrect response.
	Non-Response
90	Crossed out/erased, illegible, or impossible to interpret.
99	Blank.

Criteria for a Complete Response (Part B):

1. The student identifies at least 2 forces that act on the clown (such as air resistance, elastic force, and support force).
2. The student identifies the location at which these forces act—air resistance (B, C, D); elastic force (C); and support force (A, E).

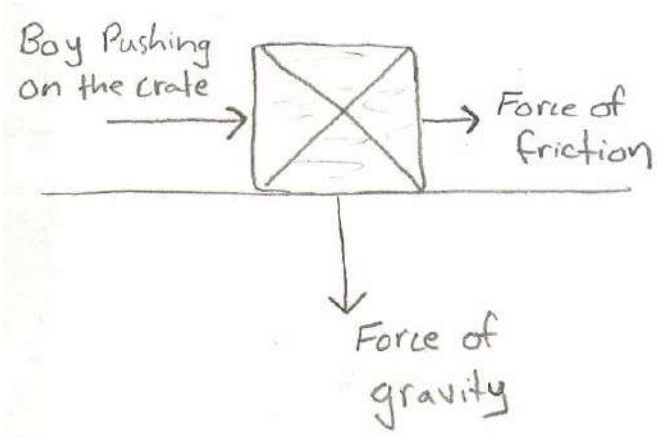
Code	Response
	Complete Response
20	Meets the criteria for a complete response.
29	Any other completely correct response.
	Partially Correct Response
10	Student identifies two correct forces but does not include the correct locations.
11	Student identifies only one correct force and its location(s).
19	Any other partially correct response.
	Incorrect Response
70	Student identifies two incorrect forces and does not include the correct locations.
71	Student identifies only one incorrect force and does not include the location of the force.
76	Repeats the stem of the question.
79	Any other incorrect response.
	Non-Response
90	Crossed out/erased, illegible, or impossible to interpret.
99	Blank.

A teacher gave her science class a test. Each student was asked to do the following:



A boy is pushing a large crate across the floor <u>at constant speed</u>. Identify all of the forces acting on the crate and then draw a force diagram. Remember that a good force diagram shows the approximate sizes and directions of all of the forces that are acting on the crate.

The student provides the following force diagram in his response:



5. Carefully review the student's force diagram and <u>label</u> all of the errors. Draw a correct force diagram that will show this student how to correctly answer this question.

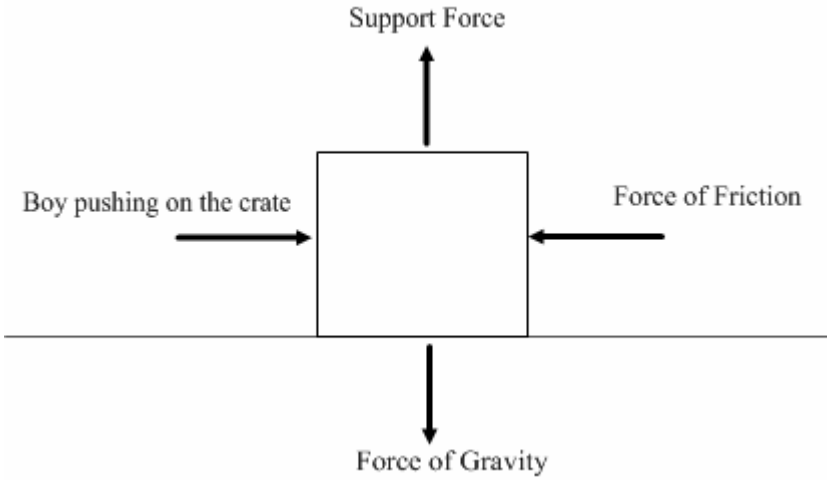
Rubric: Question #5

This item measures the student's ability to identify the forces that act on an object. It also measures the student's ability to correctly draw a force diagram for an object that is moving at constant speed (and the forces are balanced).

Criteria for a Complete Response:

1. The student identifies that the force of friction is going in the opposite direction.
2. The student identifies that the length of the force of friction arrow must be increased to match the length of the arrow representing the boy's pushing force on the box. (Alternatively, the arrow representing the boy's pushing force could be decreased to match the friction arrow).
3. The student identifies that the supporting force (or any acceptable identification of the ground pushing upwards) is needed to balance the force of gravity.
4. The student draws the supporting force arrow the same length as the force of gravity arrow.

Note: The student may directly answer each of the criterion in words, or the answer may be conveyed in the drawing of the force diagram. For example, the student may not directly state that the length of the force of friction arrow needs to increase but may draw on the "corrected" force diagram an arrow of the correct length. This response would be considered acceptable.



Code	Response
	Complete Response
30	Student meets the criteria for a complete response.
39	Any other completely correct response.
	Minimally Complete Response
20	The student meets all criteria except the identification that the force of friction is in the opposite direction.
21	The student meets all criteria except the length of the force of friction arrow needs to be addressed/changed.
22	The student meets all criteria except the identification that the supporting force is needed to balance the force of gravity.
23	The student meets all criteria except the length of the supporting force arrow and the drawing of the arrow is omitted.
	Partially Complete Response
10	The student correctly addresses only the two criteria concerning the force of friction.
11	The student correctly addresses only the two criteria concerning the supporting force.
12	The student only identifies the identification of the force of friction and supporting force errors. Correction of arrows is omitted.
19	Any other completely correct response.
	Incorrect Response
70	Student addresses only one criterion.
76	Repeats the stem of the question.
79	Any other incorrect response.
	Non-Response
90	Crossed out/erased, illegible, or impossible to interpret.
99	Blank.