MCAS Biology and Introductory Physics

Standard Setting Meeting Executive Summary

August 2022

This report summarizes the process and results of setting achievement levels for the Massachusetts Comprehensive Assessment System (MCAS) assessments for Biology and Introductory Physics. The Massachusetts Department of Elementary and Secondary Education (ESE) partnered with Cognia and Pearson (the MCAS assessment contractors) to collect recommendations for cut scores associated with the achievement levels for the MCAS assessments.

MCAS Standard Setting Process and Results

Achievement levels are used to classify student achievement on an assessment. In order to classify student achievement into the four different levels, the following components are required: 1) policy-level definitions, 2) Achievement Level Descriptors (ALDs), and 3) cut scores. Policy-level definitions provide general descriptions of the knowledge, skills, and abilities students must demonstrate to be classified into each achievement level and apply to all courses or subject areas. ALDs illustrate the achievement levels in terms that are specific to a course or subject area. Cut scores represent the lowest boundary of each achievement level on the scale.

The process of recommending performance standards for the MCAS tests was based on standard setting procedures that were used for the MCAS tests for ELA, mathematics, and grades 5 and 8 STE, was in line with national best practice, and was conducted with review and approval of the MCAS Technical Advisory Committee (TAC). Results and details of the process are presented in the following sections.

Policy-level Definitions

Policy-level definitions for the MCAS achievement levels are shown in Table 1. The titles and descriptions of the achievement levels were defined to be part of a cohesive assessment system. The achievement levels indicate a student's ability to demonstrate proficiency in relation to subject- and grade-specific expectations, as indicators of a student’s readiness for the next grade-level or college and career, as defined in the Massachusetts curriculum framework.

The Commissioner and the Board of Elementary and Secondary Education approved the final policy-level definitions for MCAS assessments in March 2017.

**Table 1. Policy-level Definitions for MCAS Achievement Levels**

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| --- | --- |
| **Achievement Level** | **Policy-level Definition** |
| **Exceeding Expectations** | A student who performed at this level exceeded grade-level expectations by demonstrating mastery of the subject matter. |
| **Meeting Expectations** | A student who performed at this level met grade-level expectations and is academically on track to succeed in the current grade in this subject. |
| **Partially Meeting Expectations** | A student who performed at this level partially met grade-level expectations in this subject. The school, in consultation with the student's parent/guardian, should consider whether the student needs additional academic assistance to succeed in this subject. |
| **Not Meeting Expectations** | A student who performed at this level did not meet grade-level expectations in this subject. The school, in consultation with the student's parent/guardian, should determine the coordinated academic assistance and/or additional instruction the student needs to succeed in this subject. |

Achievement Level Descriptors (ALDs)

Draft sets of ALDs for the Biology and Introductory Physics, shown in [Appendix A](#AppendixA), indicate the knowledge and skills that students performing at a given achievement level should be able to demonstrate within each specific content area. Descriptors were developed for the *Partially Meeting Expectations, Meeting Expectations,* and *Exceeding Expectations* only. A student classified as *Not Meeting Expectations* has not demonstrated the knowledge, skills, and abilities necessary to achieve *Partially Meeting Expectations.*

A multi-step process was used to develop, review, and approve the ALDs for each test. Prior to the standard setting meeting, the DESE science test developers created the ALDs for each content area. Curriculum and instruction staff from DESE’s Center for Instructional Support reviewed and commented on the ALDs. In addition, test developers from DESE’s testing contractor, Cognia, reviewed and commented on the drafts. Finally, educators from DESE’s Biology and Introductory Physics Assessment Development Committees (former and current members) reviewed and edited the drafts. These educators reviewed their content area ALDs and then reviewed the ALDs from the other content area. For example, Biology educators reviewed the Biology ALDs first and then reviewed the Introductory Physics ALDs. The educators first discussed their content area ALDs within their content area. This was followed by a whole group meeting of both sets of educators comparing the two sets of ALDs. The reason for the comparison between the content areas was to ensure similar rigor and expectations for each test at each achievement level. A final summary report of the ALD meeting will be included in the full standard setting report.

Teachers who participated in the standard setting committees had the opportunity to provide suggestions and edits to the draft set of ALDs. To produce the final ALDs, DESE science test developers will edit the draft ALDs based on suggestions generated by the participants in the standard setting meeting.

Cut Scores

The cut scores that were recommended for adoption for the MCAS assessments are based on a standardized set of procedures implemented during the standard setting meetings. General methods used during the meeting for obtaining the recommended cut scores are provided below.

Standard Setting Meeting

From August 9 to August 11, 2022, after the first year of operational administration in spring 2022, a standard setting meeting was conducted to obtain cut score recommendations for the next-generation high school science MCAS tests. There were two committees, with each recommending cut scores for one test:

* Biology
* Introductory Physics

Each committee was composed of 19 individuals, including teachers and non-teacher educators (e.g., administrators, curriculum specialists, professors of higher education). The participants were selected for the standard setting committee to provide content expertise during the committee meeting and to be representative of the state teaching population, including geographic region, gender, ethnicity, educational experience, community size, and community socioeconomic status.

The Extended Modified (Yes/No) Angoff method was used for the standard setting meeting (Davis & Moyer, 2015; Plake, Ferdous, Impara, & Buckendahl, 2005). This is a content- and item-based method that leads participants through a standardized process through which they consider student expectations, as defined by ALDs, and the individual items administered to students to recommend cut scores for each achievement level. The standardized process was used by the committees for each subject.

The process started with participants experiencing the test from the spring 2022 administration within the online testing system. Based on their experience with the test items and a review of the draft ALDs, panelists created borderline descriptions. During this process, participants worked within their committees to modify the draft ALDs to create descriptors of the knowledge, skills, and abilities that “borderline” students, or those students who just barely enter an achievement level, would be expected to demonstrate.

During the judgment process, participants reviewed each item on the test, referencing the borderline descriptions, and answered the following question for each achievement level:

“How many points would a student with performance at the borderline of the [specific] achievement level likely earn if he or she answered the question?”

The cut score recommendation for each individual participant was the expected raw score a borderline student at the respective achievement level would likely earn, calculated as the sum of the individual item judgments. For the purposes of the standard setting, “likely” was defined as 2 out 3 students at the borderline level. Each recommended cut score from the standard setting committee was the median of the recommendations from the individual participants in the committee.

Additionally, the percentage of students who would be classified into each achievement level based on committee recommendations—also known as impact data—was calculated. The impact data were determined using student data from the spring 2022 online administration. As part of the discussion of the round 2 judgments, the impact data were presented, based on the round 2 recommendations, so the participants could see the resulting student achievement level classifications prior to making their round 3 recommendations. This information was also presented after the round 3 cut score recommendations were calculated.

The results (Round 3 recommendations) from the standard setting meeting for the Biology and Introductory Physics panels are presented in Table 2.

**Table 2. Standard Setting Recommendations for Biology and Introductory Physics (Round 3)**

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| --- | --- |
| **Subject** | **Achievement Level** |
| **Not Meeting Expectations** | **Partially Meeting Expectations** | **Meeting Expectations** | **Exceeding Expectations** |
| **Raw Score Range** | **% in Level** | **Raw Score Range** | **% in Level** | **Raw Score Range** | **% in Level** | **Raw Score Range** | **% in Level** |
| Biology | 0 to 16 | 20 | 17 to 36 | 45 | 37 to 51 | 28 | 52 to 60 | 7 |
| Introductory Physics | 0 to 15 | 11 | 16 to 36 | 47 | 37 to 50 | 31 | 51 to 60 | 11 |

Figure 1 presents the impact data from the final recommendations (Round 3) from the standard setting meeting as stacked bar graphs.

**Figure 1. Impact Data for Biology and Introductory Physics Tests based on Standard Setting Recommendations from Round 3**

Vertical and Horizontal Articulation Meeting

Subsequent to the standard setting meeting, on August 12, 2022, a vertical and horizontal articulation meeting was convened. The meeting consisted of one committee that reviewed the cut score recommendations from the Biology and Introductory Physics panels. The participants of the articulation meeting consisted of table leaders and other standard setting panel members selected prior to the standard setting meeting. The focus of the articulation meeting was to review the cut score recommendations from the standard setting meeting along with impact data to consider whether and to what extent adjustments to the recommended cut scores might be warranted based on both content and policy. In addition to the impact data for Biology and Introductory Physics, impact data for the Grade 8 STE test from the spring 2019 administration and matched data from 2022 Biology and Introductory Physics tests were presented to compare results both across grades and between subjects. The matched data was created using a statistical process to present impact data for both subjects based on students with statistically similar ability distributions. The adjustments to the recommendations made by the articulation committee were influenced by a desire to honor the content-based recommendations of the standard setting process, maintain high expectations for achievement across the MCAS assessments, and ensure the relationship among standards was coherent and defensible.

Tables 3 presents the results from the vertical and horizontal articulation meeting.

**Table 3. Recommendations for Biology and Introductory Physics from the Vertical and Horizontal Articulation Meeting Recommendations**

|  |  |
| --- | --- |
| **Subject** | **Achievement Level** |
| **Not Meeting Expectations** | **Partially Meeting Expectations** | **Meeting Expectations** | **Exceeding Expectations** |
| **Raw Score Range** | **% in Level** | **Raw Score Range** | **% in Level** | **Raw Score Range** | **% in Level** | **Raw Score Range** | **% in Level** |
| Biology | 0 to 15 | 18 | 16 to 33 | 41 | 34 to 50 | 33 | 51 to 60 | 8 |
| Introductory Physics | 0 to 16 | 13 | 17 to 34 | 40 | 35 to 51 | 37 | 52 to 60 | 10 |

Figure 2 presents the impact data from the recommendations from the articulation meeting as stacked bar graphs, including the matched data for Biology and Introductory Physics.

Figure 2. Impact Data for Biology and Introductory Physics based on the Articulation Meeting Recommendations

Scaling

The process of determining the transformation rules from the Item Response Theory (IRT) scale to the reporting scale was guided by several principals identified by DESE:

1. The final cut scores achieved through the scaling solution should respect the cut score recommendations from the standard setting and articulation panels as closely as possible.
2. The impact data from the scaling solution should reflect a coherent assessment system across the grades.
3. The reporting scaled scores for the three achievement level cuts should be the same across grades and tests.
4. The scaling solution should involve a single linear transformation, from the IRT scale to the reporting scale.
5. The reporting scaled score range should be the same across grades and tests.

An iterative process involving Pearson, Cognia, and DESE was used to determine a scale and transformation rules for each test. First, based on the recommended raw score cuts for the three achievement levels, the IRT scale cuts were adjusted so that the differences between every two IRT scale cuts were the same, allowing for a single linear transformation rule. Based on the adjusted IRT cut scores, scaling constants for the linear transformation were determined. Using the scaling constants, look-up tables for each grade and test were created, displaying the relationship between the raw scores and reporting scaled scores. Based on the look-up tables, adjusted raw score cuts for each achievement level were determined. Finally, the resulting impact data based on the adjusted raw score cuts were calculated and reviewed to ensure a coherent system across grades.

The recommended reporting scale ranges from a lowest obtainable scale score of 440 to a highest obtainable scale score of 560. In order to create common points of reference across the assessments, the same scaled score cuts for each achievement level were defined, with a *Partially Meeting Expectations* cut of 470, a *Meeting Expectations* cut of 500, and an *Exceeding Expectations* cut of 530. While the cut scores were defined with the same scaled scores between the two tests, they are not identical, and direct comparisons through averaging and aggregation across grades should not be made without study and/or statistical adjustments. The scaled scores and distributions of students resulting from the cuts set for biology and introductory physics were not designed for direct comparison.

After the standard setting meeting, there was a discussion among DESE, Pearson, and Cognia staff about the results from the articulation and scaling. As a result of a need to bring the Biology more inline with content expectations from the standard setting committee, the Partially Meeting cut was raised to 17. As a result, the Exceeding cut was lowered to 50 and the Meeting cut was lowered to 34 to ensure proper scaling. Additionally, to bring the Introductory Physics more inline with the content expectations from the standard setting committee, the Partially Meeting cut was changed to 17. Table 3 presents the achievement level cut scores based on these changes.

**Table 3. Final Recommendations for Biology and Introductory Physics Tests**

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| --- | --- |
| **Subject** | **Achievement Level** |
| **Not Meeting Expectations** | **Partially Meeting Expectations** | **Meeting Expectations** | **Exceeding Expectations** |
| **Raw Score Range** | **% in Level** | **Raw Score Range** | **% in Level** | **Raw Score Range** | **% in Level** | **Raw Score Range** | **% in Level** |
| Biology | 0 to 16 | 20 | 17 to 33 | 38 | 34 to 49 | 32 | 50 to 60 | 10 |
| Introductory Physics | 0 to 16 | 14 | 17 to 34 | 40 | 35 to 50 | 35 | 51 to 60 | 11 |

Figure 3 presents the impact data from the final recommendations as stacked bar graphs.

**Figure 3. Impact Data for Biology and Introductory Physics based on Final Recommendations**

The final approved result from this standard setting will be used for future administrations of the MCAS Biology and Introductory Physics tests to classify student results into achievement levels for reporting until it is determined that new standards need to be established for the MCAS by the DESE. To assist in this, the achievement level cut scores as raw scores are translated into achievement level cut scores on the item response theory (IRT) ability scale, as shown in Table 4. These values are uses to establish the scaling constants, A and B, to translate student scores on the IRT ability scale to the reporting scale.

**Table 4. Achievement Level Cut Scores and Scaling Constants**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Cut Scores (Raw Score)** | **Cut Scores (IRT)** | **Scaling Constants** |
| **Subject** | **PME** | **ME** | **EE** | **PME** | **ME** | **EE** | **A** | **B** |
| Biology | 17 | 34 | 50 | -0.8500 | 0.2100 | 1.3000 | 27.90698 | 493.7209 |
| Introductory Physics | 17 | 35 | 51 | -1.0100 | 0.1200 | 1.2600 | 26.43172 | 496.6960 |

Note: PME – Partially Meeting Expectations; ME – Meeting Expectations; EE – Exceeding Expectations

Interim Legacy Achievement Cut Score Validation

On the previous (“legacy”) version of the Biology and Introductory Physics MCAS tests, a student was required for graduation to earn a Competency Determination (CD) by receiving a minimum scaled score of 220. As part of the transition to the next-generation MCAS, the Board of Elementary and Secondary Education voted to establish an interim CD standard for high school graduation. Interim standards would be defined as a similar level of achievement to the required standards on the legacy tests. Students in the classes of 2022 through 2025 taking the next-generation MCAS would be evaluated against the interim standards on each test

The interim legacy achievement level standards were first identified through a statistical linking process. An equipercentile linking method was used to statistically establish an association between the raw scores from the spring 2019 and spring 2022 administrations of the MCAS tests. This was accomplished through determining the raw scores on the spring 2022 administration of the next-generation MCAS which would result in percentiles equal to those associated with the raw scores for each of the achievement levels from the spring 2019 administration of the legacy MCAS tests. Using the result of the equipercentile analysis, standard errors of measures for the raw scores, and statistical results from the test construction process, recommended ranges for raw scores associated were determined for each achievement level cut score.

After the standard setting panels completed their cut score recommendations, a subset of panelists were convened to recommend interim legacy MCAS achievement level cut scores from recommended ranges. The panelists reviewed the performance of students from the spring 2019 administration on the legacy MCAS to determine general descriptions of the achievement of students at the borderline of each legacy achievement level. The general descriptions were then used by the panelists to review the performance of students within the raw score ranges from the spring 2022 administration on the next-generation MCAS. Based on their review, the panelists completed a judgment survey where they answered the following question:

“Based on your review, which raw score within the recommended range for the achievement level on the Next-Generation MCAS test most closely represents a similar achievement level on the legacy assessment?”

Panelists provided individual recommendations for each achievement level, Needs Improvement, Proficient, and Advanced. The median of the committee recommendations was used as the committee recommendation for the achievement level. Table 4 displays the interim cut score recommendations for the legacy achievement levels on the next-generation MCAS.

**Table 4. Recommended Cut Scores for the Legacy Achievement Levels**

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| --- | --- |
| **Subject** | **Legacy Achievement Levels** |
| **Needs Improvement** | **Proficient** | **Advanced** |
| Biology | 16 | 29 | 46 |
| Introductory Physics | 17 | 29 | 47 |

References

Davis, L. L. & Moyer, E. L. (2015). PARCC performance level setting technical report. Available from Partnership for Assessment of Readiness for College and Careers (PARCC), Washington, D.C.

Plake, B. S., Ferdous, A. A., Impara, J. C., & Buckendahl, C. W. (2005). *Setting Multiple Performance Standards Using the Yes/No Method: An Alternative Item Mapping Method.* Meeting of the National Council on Measurement in Education*.* Montreal, Canada.

Appendix A – Draft Achievement Level Descriptors

Biology ALDs

Student results on the MCAS tests are reported according to four achievement levels: *Exceeding Expectations, Meeting Expectations, Partially Meeting Expectations,* and *Not Meeting Expectations.* The descriptors below illustrate the knowledge and skills students demonstrate on MCAS at each level. **Knowledge and skills are cumulative at each level.** No descriptors are provided for the *Not Meeting Expectations* achievement level because students work at this level, by definition, does not meet the criteria of the *Partially Meeting Expectations* level.

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|   | **Partially Meeting Expectations *On MCAS, a student at this level:***  | **Meeting Expectations**  ***On MCAS, a student at this level:***  | **Exceeding Expectations**  ***On MCAS, a student at this level:***  |
| **Understanding and Application of Disciplinary Core Ideas**  | Demonstrates a partial understanding of some scientific concepts and processes by identifying and sometimes describing or providing evidence for these concepts and processes.  Uses some basic scientific terms in common scientific examples.  | Demonstrates a solid understanding of many scientific concepts and processes by mostly describing, explaining, and providing evidence for these concepts and processes.  Mostly applies appropriate scientific terms in a variety of applications, including common science examples and some novel situations.  | Demonstrates a comprehensive, in-depth understanding of many scientific concepts and processes by consistently describing, explaining, and providing evidence for these concepts and processes.  Consistently applies scientific terms in appropriate contexts in both common science examples and many novel situations.  |
| **Understanding and Application of Scientific and Engineering Practices**  | Identifies a testable, scientific question for an investigation.  Completes a simple, commonly used model.  Uses simple graphs or data to draw general conclusions about a familiar scientific investigation or phenomena.  Identifies evidence to support a claim.  Describes a benefit or drawback of simple design features given a familiar device or prototype.  | Develops some testable, scientific questions for an investigation.  Completes or uses a model and describes some strengths and weaknesses of the model.  Analyzes multiple sources of data, including graphs and tables, to draw conclusions about a familiar scientific investigation or phenomena.  Provides some evidence to support a claim and constructs basic explanations for scientific phenomena or results from an investigation.  Analyzes design features of a familiar device or prototype and describes a benefit or drawback of the design.  | Consistently develops testable, scientific questions for an investigation.  Creates a model, consistently describes the strengths and weaknesses of the model, and provides information for how to improve the model.  Analyzes multiple sources of data, including graphs and tables, to draw conclusions about a novel or complex scientific investigation or phenomena.  Provides several pieces of evidence to support a claim and constructs thorough explanations for scientific phenomena or results from an investigation.  Analyzes design features of a novel device or prototype and constructs an explanation for how the design features meet criteria for success or are limited by constraints.  |

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| **LS1. From Molecules to Organisms: Structures and Processes**  |
| **Partially Meeting Expectations** ***On MCAS, a student at this level:***  | **Meeting Expectations** ***On MCAS, a student at this level:***  | **Exceeding Expectations** ***On MCAS, a student at this level:***  |
| Identifies some of the most common elements that make up organic macromolecules.   Describes a basic function of a type of organic macromolecule (carbohydrate, lipid, nucleic acid, or protein).  Identifies the source of energy and the major reactants and products of photosynthesis by their names or chemical formulas.  Describes ATP as a source of usable energy and that it is produced in mitochondria.  Describes some major events of the cell cycle (including interphase, mitosis, cytokinesis) and their purposes.  Identifies complementary base pairs for a DNA sequence and for an mRNA sequence.  Identifies that a gene codes for a protein and describes one function of a protein.  Completes a basic model to generally describe how a body system works.  Describes one way the body maintains homeostasis.   | Analyzes models to classify most organic macromolecules and identifies all common elements for a given example.    Analyzes models of monomers to determine some types of organic macromolecules and describes some basic functions of these macromolecules.  Constructs or completes models of photosynthesis using the names or chemical formulas of reactants and products and describes the importance of photosynthesis.   Constructs or completes models of cellular respiration using the names or chemical formulas of reactants and products and describes the importance of cellular respiration.   Completes a model to describe how major events of the cell cycle, including DNA replication, allow a cell to grow and survive.   Describes the structure of DNA and how its structure affects its function.   Describes how genes code for proteins through transcription and translation and describes several functions of proteins.  Recognizes that all cells within the same organism have the same genes.  Describes several functions of proteins. Describes the functions of structures and organs of body systems. Interprets models to draw a conclusion about the way the human body maintains homeostasis.   | Analyzes models of monomers to consistently identifies their organic macromolecules and describes the functions of these molecules.  Constructs an explanation about the important uses of the products of photosynthesis for both plants and animals.  Analyzes data to determine the relative amount of ATP that is generated by organisms under different conditions.   Explains how ATP is used in a variety of ways by both animal and plant cells.   Constructs an explanation about how the sequence of events of the cell cycle allows organisms to grow and survive.  Describes specific functions of several proteins, including enzymes, hormones, and structural proteins.  Calculates the percentage of one type of nitrogenous base for a DNA molecule using complementary base pairs.  Analyzes and creates models of DNA, RNA, and amino acid chains to describe the products of replication, transcription, or translation.  Analyzes data to determine when a gene is expressed and to determine whether replication, transcription, or translation occurs.   Constructs an explanation about why different types of cells express different genes, which results in different cell functions.  Analyzes data to draw conclusions about how body systems work together to support life functions.   Constructs explanations about how body systems work to restore homeostasis when conditions change.   |

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| **LS2. Ecosystems: Interactions, Energy, and Dynamics**  |
| **Partially Meeting Expectations** ***On MCAS, a student at this level:***  | **Meeting Expectations** ***On MCAS, a student at this level:***  | **Exceeding Expectations** ***On MCAS, a student at this level:***  |
| Describes birth and immigration as factors that increase population size, and death and emigration as factors that decrease population size.  Identifies some basic ecological relationships (such as predation, competition, mutualism), when given an example.  Interprets a basic food web to identify simple ecological relationships.  Analyzes a food web to identify the trophic level of a species.  Recognizes that less energy is available at higher tropic levels in an energy pyramid.  Identifies some carbon cycle processes and recognizes that carbon is released or stored in the environment depending on the process.  Recognizes that the biodiversity of an ecosystem is affected by the number of species in the ecosystem.   Describes one way invasive species can impact other species in an ecosystem.   Identifies human impacts (climate change, pollution, habitat destruction) on an ecosystem and describes some ways to address them.  | Describes how various biotic and abiotic factors affect a population’s birth rate, death rate, immigration rate, or emigration rate.    Describes several ecological relationships and determines evidence that supports claims about ecological relationships.  Analyzes a food web to describe changes to populations resulting from an increase or decrease of another population.  Uses an energy pyramid to calculate the amount of energy that is expected to be stored in different trophic levels.  Completes a carbon cycle model showing how carbon is moved through both biotic and abiotic parts of an ecosystem.   Describes how the biodiversity of an ecosystem is affected by the number of individuals within a species (genetic diversity is lower in smaller populations).  Describes some characteristics of invasive species and how these characteristics can affect other species in an ecosystem.  Analyzes data to determine the human impact on an ecosystem and describes several ways to   reduce the impact of human activity on the ecosystem.  | Analyzes multiple factors (such as species interactions, human activities, and natural phenomena) to solve problems relating to population size and carrying capacity of an ecosystem.  Analyzes complex food webs and constructs explanations about various interactions in the food web as the sizes of populations change.   Constructs an explanation for why only about 10% of the energy stored in one trophic level will be available to the next higher trophic level and how having less energy available reduces the number of organisms that can be supported at higher trophic levels.  Constructs an explanation for how several carbon cycle processes interact within an ecosystem and how changes in the environment can disrupt the cycle.  Explains how biodiversity of an ecosystem can be impacted by both the number of species in that ecosystem as well as the number of individuals within a species.   Constructs thorough explanations for how and why invasive species can affect an ecosystem.  Evaluates several solutions for either reducing the impact of human activity on an ecosystem or restoring an ecosystem and explains the benefits and drawbacks of these solutions.  |
| **LS3. Heredity**  |
| **Partially Meeting Expectations** ***On MCAS, a student at this level:***  | **Meeting Expectations** ***On MCAS, a student at this level:***  | **Exceeding Expectations** ***On MCAS, a student at this level:***  |
| Identifies the general purpose of meiosis, that gametes come from two parents, and that egg and sperm combine to produce offspring.    Recognizes that inherited traits are encoded in an organism’s DNA and RNA.  Completes a simple model to show how a mutation in a DNA sequence can change an mRNA codon.   Identifies that only mutations in a gamete can be passed from parent to offspring and that mutations can be a source of genetic diversity.  Identifies simple inheritance patterns for a given trait.  Identifies genotypes for a certain trait, completes a Punnett square for a given cross, and calculates the expected percentage of offspring for a given genotype or phenotype.   Identifies the genotype of an individual in a basic pedigree when the inheritance pattern is given.  | Analyzes and completes a basic model of meiosis.    Describes the product of fertilization as a zygote (a diploid cell) containing genetic information from both parents.    Describes how mutations in DNA can lead to the production of different amino acids and therefore different proteins.  Interprets a model of crossing over and concludes that genetic variability increases as a result of crossing over.  Interprets information to consistently determine inheritance patterns.  Constructs and completes Punnett squares and calculates the expected percentages of genotypes and phenotypes of crosses for a given scenario.   Analyzes a pedigree to determine the inheritance pattern of a trait.  Describes how polygenic traits are influenced by the expression of multiple genes.  Describes how environmental factors can influence the expression of some inherited traits.      | Constructs an explanation of why meiosis is important for maintaining the number of chromosomes from one generation to the next.  Explains how crossing over, independent assortment, and random pairing of gametes contribute to the genetic diversity of offspring.   Constructs an explanation for how a mutation in a DNA code may or may not result in a phenotypic (trait) change.  Analyzes Punnett squares to determine the expected genotype and phenotype percentages for sex-linked traits.  Analyzes a complex pedigree to determine genotypes and phenotypes of individuals and to make predictions about future offspring of parents in the pedigree.  Uses data to explain the likelihood that a certain trait will be more influenced by genetics or by the environment.   |

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| **LS4. Evolution**  |
| **Partially Meeting Expectations** ***On MCAS, a student at this level:***  | **Meeting Expectations** ***On MCAS, a student at this level:***  | **Exceeding Expectations** ***On MCAS, a student at this level:***  |
| Identifies some types of evidence (genomes, amino acids, fossils, homologous structures) that support the process of evolution.   Recognizes that individuals with certain traits survive and produce more offspring than individuals without those traits.  Describes that, in general, two organisms from the same species are able to mate and produce offspring.  Recognizes that isolated populations generally have a smaller gene pool than larger populations.  Recognizes that viruses are unable to reproduce outside of a host cell and that bacteria reproduce through asexual reproduction.   | Explains how evolution can be supported by evidence that demonstrates common ancestry.    Completes a cladogram to show the evolutionary relationships among several species.  Describes how an advantageous heritable trait allows individuals in a population to survive and reproduce more than individuals without that trait.  Describes how to determine whether two organisms are closely related and/or from the same species.    Describes the role of genetic drift or gene flow in the speciation or extinction of a population.   Describes how bacteria and viruses adapt quickly to changing environments due to their high mutation rate and the ability to quickly reproduce.   | Constructs an explanation based on a model, such as a cladogram, to support a claim about the evolutionary relatedness of species and explains why comparing genomes provides the best evidence that two species are closely related.  Constructs a thorough explanation about evolution, including conditions (heritable variation, differential fitness) that need to be met for evolution to occur and how there will be changes in the frequency of alleles (or traits) within a population over time.   Analyzes a situation to determine evidence of selection pressures that could influence the evolution of a population.  Constructs explanations based on data for how genetic drift, gene flow, mutations, and natural selection can play a role in the speciation or extinction of a population.   Analyzes the results of an investigation to determine conditions that will support the growth of bacteria or viruses.    |

Introductory Physics ALDs

Student results on the MCAS tests are reported according to four achievement levels: *Exceeding Expectations, Meeting Expectations, Partially Meeting Expectations,* and *Not Meeting Expectations.* The descriptors below illustrate the knowledge and skills students demonstrate on MCAS at each level. **Knowledge and skills are cumulative at each level.** No descriptors are provided for the *Not Meeting Expectations* achievement level because students work at this level, by definition, does not meet the criteria of the *Partially Meeting Expectations* level.

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| --- | --- | --- | --- |
|   | **Partially Meeting Expectations**  ***On MCAS, a student at this level:***  | **Meeting Expectations**  ***On MCAS, a student at this level:***  | **Exceeding Expectations**  ***On MCAS, a student at this level:***  |
| **Understanding and Application of Disciplinary Core Ideas**  | Demonstrates a partial understanding of some scientific concepts and processes by identifying and sometimes describing or providing evidence for these concepts and processes.  Uses some basic scientific terms in common scientific examples.  | Demonstrates a solid understanding of many scientific concepts and processes by mostly describing, explaining, and providing evidence for these concepts and processes.  Mostly applies appropriate scientific terms in a variety of applications, including common science examples and some novel situations.  | Demonstrates a comprehensive, in-depth understanding of many scientific concepts and processes by consistently describing, explaining, and providing evidence for these concepts and processes.  Consistently applies scientific terms in appropriate contexts in both common science examples and many novel situations.  |
| **Understanding and Application of Scientific and Engineering Practices**  | Identifies a testable, scientific question for an investigation.  Completes a simple, commonly used model.  Uses simple graphs or data to draw general conclusions about a familiar scientific investigation or phenomena.  Identifies evidence to support a claim.  Describes a benefit or drawback of simple design features given a familiar device or prototype.  | Develops some testable, scientific questions for an investigation.  Completes or uses a model and describes some strengths and weaknesses of the model.  Analyzes multiple sources of data, including graphs and tables, to draw conclusions about a familiar scientific investigation or phenomena.  Provides some evidence to support a claim and constructs basic explanations for scientific phenomena or results from an investigation.  Analyzes design features of a familiar device or prototype and describes a benefit or drawback of the design.  | Consistently develops testable, scientific questions for an investigation.  Creates a model, consistently describes the strengths and weaknesses of the model, and provides information for how to improve the model.  Analyzes multiple sources of data, including graphs and tables, to draw conclusions about a novel or complex scientific investigation or phenomena.  Provides several pieces of evidence to support a claim and constructs thorough explanations for scientific phenomena or results from an investigation.  Analyzes design features of a novel device or prototype and constructs an explanation for how the design features meet criteria for success or are limited by constraints.  |

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| **PS1. Matter and Its Interactions**  |
| **Partially Meeting Expectations** ***On MCAS, a student at this level:***  | **Meeting Expectations** ***On MCAS, a student at this level:***  | **Exceeding Expectations** ***On MCAS, a student at this level:***  |
| Interprets a model to determine that energy is released during the processes of fission, fusion, and radioactive decay.  | Analyzes a model to determine whether fission, fusion, or a radioactive decay (alpha, beta, or gamma) process occurred.  | Analyzes incomplete models of fission, fusion, and radioactive decay and describes the results of each in terms of energy and products.  |

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| **PS2. Motion and Stability: Forces and Interactions**  |
| **Partially Meeting Expectations** ***On MCAS, a student at this level:***  | **Meeting Expectations** ***On MCAS, a student at this level:***  | **Exceeding Expectations** ***On MCAS, a student at this level:***  |
| Solves simple problems involving average speed, velocity, and acceleration.   Interprets a motion graph to determine how the graphed variable changes over time.   Interprets a scenario to determine the relative magnitude of a force.  Determines a net force using Newton’s 2nd law or by interpreting a free-body force diagram with two colinear forces.  Solves simple momentum and change in momentum (impulse) problems.   Interprets a model to determine whether two charges will attract or repel.   Describes how the magnitude of charges or the distance between charges affects electrostatic forces.  Describes how the masses of objects or the distance between objects affects gravitational forces.    Solves simple problems using Ohm’s Law when given two of the three variables (current, voltage, or resistance).  Identifies a schematic symbol for a simple circuit element and generally explains its role.    | Solves problems involving acceleration, velocity, and change in position for a given time.   Analyzes motion graphs and their slopes to solve for and compare speeds, velocities, accelerations, and net forces.  Analyzes free-body force diagrams to determine which diagram represents a given system.  Solves for an unknown force by interpreting a model with two or more colinear forces when also given the net force.   Solves for the total momentum or change in momentum of a system.  Interprets a model to determine the direction an object will move after a collision.  Compares the magnitude and the direction of the forces that two objects exert on each other when they collide.    Compares models of pairs of masses or charges to order the magnitude of the gravitational or electrostatic forces.  Completes a model to represent electrostatic forces between charges.  Interprets a model to support a claim that an electric current produces a magnetic field or a claim that a changing magnetic field produces an electric current.  Describes how a change to a circuit affects current, voltage, or resistance.  Interprets a series circuit diagram with several circuit elements and solves for current, resistance, or voltage.  Interprets simple series or parallel circuit diagrams and explains which circuit elements will have the same current through them and which elements will have the same voltage drop across them.   | Solves a motion problem by analyzing a model and then applying information from the model to solve for velocity or acceleration.  Explains how changing a system would affect an object’s velocity or acceleration.  Solves force problems by analyzing motion graphs and then models the forces involved using free-body force diagrams.   Analyzes a motion graph and then applies information from the graph to solve a momentum problem.   Describes that the total momentum of a system stays the same during a collision and solves for velocity or mass by applying conservation of momentum.  Explains how forces involved in a collision can be minimized.  Applies proportional reasoning to solve for how changing the distance between a pair of masses or a pair of charges affects the forces between the pair.  Applies proportional reasoning when multiple variables are changed to determine the forces between a pair of masses or charges.   Describes the effect of a gravitational or electrostatic force between two objects by solving for the force using either Newton’s law of gravitation or Coulomb’s law.  Explains that the interplay of electric and magnetic forces is the basis for electric motors and generators.   Analyzes series and parallel circuit diagrams with multiple circuit elements to compare and solve for current, voltage, and resistance.   |

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| **PS3. Energy**  |
| **Partially Meeting Expectations** ***On MCAS, a student at this level:***  | **Meeting Expectations** ***On MCAS, a student at this level:***  | **Exceeding Expectations** ***On MCAS, a student at this level:***  |
| Solves for gravitational potential energy when given the height and mass of an object.  Describes an example of energy being converted from one form to another.  Interprets a model to determine a location where gravitational potential energy or kinetic energy is either the greatest or the least.  Solves simple problems for work when given the force and distance.  Solves efficiency problems when given energy in and energy out.  Interprets a simple graph to determine when thermal equilibrium is reached.  Recognizes that heat flows from a substance with a higher temperature to a substance with a lower temperature.  Recognizes the relationship between average molecular motion and temperature.  Describes the relative amount of force between two magnets as they are moved closer together or farther apart.  | Analyzes a model of a system and then uses information from the model to calculate kinetic energy or gravitational potential energy.  Describes that energy cannot be created or destroyed, but energy may enter or leave a system.  Compares an object’s kinetic energy at two positions or an object’s potential energy at two positions when mechanical energy is conserved.   Analyzes data to solve mechanical energy problems.  Interprets a model of a device and explains how to increase the efficiency of the device.  Explains how the temperatures in two substances change as the substances reach thermal equilibrium.  Describes how changing the mass of a substance affects the energy required to cause a temperature change.  Analyzes electric field diagrams and determines the direction and relative strength of the electric field around two charges.  Explains how the energy stored in a field between two magnets or two charges changes when they are moved different distances apart.  | Constructs an explanation for how kinetic energy and potential energy change over time in a given model.  Explains how the mechanical energy of a system can change, due to work being done on the system by a force, while maintaining the law of conservation of energy.  Solves complex work problems, including first solving for initial and final mechanical energy.  Analyzes a graph to compare the energy efficiency of multiple devices.  Explains how the average molecular motion of molecules in two substances changes as the substances reach thermal equilibrium, and how energy is conserved in a system as thermal equilibrium is reached.  Analyzes a model and solves problems for the amount of heat transferred in a system, the specific heat of a substance, or the initial or final temperature of a substance.  Interprets a model to describe the motion of a freely moving charged particle and the energy stored in the field between two charged particles.  |

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| **PS4. Waves and Their Applications in Technologies for Information Transfer**  |
| **Partially Meeting Expectations** ***On MCAS, a student at this level:***  | **Meeting Expectations** ***On MCAS, a student at this level:***  | **Exceeding Expectations** ***On MCAS, a student at this level:***  |
| Solves simple wave problems for velocity/speed, wavelength, or frequency when given two of these three variables.  Identifies the wavelength of a wave on a model.  Solves simple wave problems involving period and frequency when given one of the variables.  Identifies differences between mechanical waves and electromagnetic waves.  Recognizes the relationships between frequency and pitch of a sound wave as well as between frequency and energy of a light wave.  Identifies evidence of light behaving like a wave or light behaving like a particle.    Interprets simple models of the photoelectric effect.   Interprets simple models of common wave behaviors, including resonance, diffraction, refraction, and interference.  | Analyzes data to determine additional information needed to solve wave problems.   Describes how the particles in a medium move when a longitudinal or transverse wave travels through the medium.   Describes several properties of mechanical waves and electromagnetic waves.  Compares multiple electromagnetic waves in terms of frequency, energy, and wavelength.  Analyzes a model and explains the causes of resonance and refraction.  Analyzes a model of a technology or device and describes how wave behaviors or the photoelectric effect are used in the technology or device.  | Analyzes models of waves and uses information from the models to solve problems.  Interprets a graph with relative speeds of mechanical waves to determine the states of matter of various media.  Constructs an explanation with evidence about how light can behave like a wave and how it can behave like a particle.   Explains the relationship between photon energy and the electrons ejected by the photoelectric effect.   Analyzes a model of constructive and destructive interference and determines the amplitude of a wave pulse that results from the interference.  Analyzes how a technology or device uses waves and describes how changing the properties of the waves would influence the device.  |