The University of the State of New York
REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING/PHYSICS

RATING GUIDE

For Parts B-2 and C

2015 Edition

THE STATE EDUCATION DEPARTMENT

THE UNIVERSITY OF THE STATE OF NEW YORK

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To: Regents Physical Setting/Physics Teachers

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The 2015 edition of the rating guide contains significant updates to the 2002 edition and is intended to provide assistance to teachers in rating the answers to Parts B-2 and C of the Regents Examination in Physical Setting/Physics. It is designed for use as a supplement to the official scoring key and rating guide provided with the examination. It should be saved and referred to for future rating sessions. Rating instructions included in the scoring key and rating guide or in the examination booklet take precedence over the suggestions made in this guide.

An informational copy of the rating guide is also being sent to district superintendents and superintendents, principals of public and nonpublic schools, and leaders of charter schools.

Any questions concerning the information provided in the rating guide should be directed to the Office of Curriculum and Instruction (telephone: 518-474-5922 or email: emscurric@nysed.gov), or the Office of State Assessment (telephone: 518-474-5900 or email: emscassessinfo@nysed.gov.)

INTRODUCTION

This guide provides a set of directions, along with some examples, to assist teachers in rating the answers to Parts B-2 and C of the Regents Examination in Physical Setting/Physics. While it is not possible to anticipate all the possible questions that may arise, the suggestions and examples in this guide deal with those that tend to occur most frequently.

In all work in Physical Setting/Physics, the aim should be accuracy—not only in the mechanical aspects, but also in the aspects that require concept understanding, reasoning, judgment, and application. In every instance where an error occurs, allowing proper credit requires that careful consideration be given to the relative importance of these aspects in the question.

The principal of each school administering the examination is responsible for establishing rating procedures that will assure reasonable confidence in the accuracy of the scores assigned to the Part B-2 and C answers by individual teachers. The criterion in all cases is that the rating assigned to a student's answers is a fair and accurate rating of those answers.

The scoring key and rating guide provided by the Department is the official key and teachers must rate according to this key. Credit may be allowed for other answers only if they are equivalent to the key answer. Any special ruling or rating that is indicated on the Regents examination or scoring key and rating guide takes precedence over any suggestion made in this guide and is not considered to be conflicting.

The material in this rating guide is divided into two sections: General Guidelines for Rating and Specific Rating Criteria (single-step calculations, multistep calculations, use of different symbols and equations, use of units, graphs, ray diagrams, vector diagrams, drawing of wave forms, orders of magnitude, and teacher discretion). The Specific Rating Criteria section presents examples of rating problems and acceptable solutions to these problems.

GENERAL GUIDELINES FOR RATING

1. Follow all instructions in the *Information Booklet for Administering and Scoring Regents Examinations in the Sciences*, available on the State Education Department website at http://www.p12.nysed.gov/assessment/hsgen/, and on the scoring key and rating guide that is provided with the examination.

2. First work through the questions in Parts B-2 and C and construct your own answer key. Compare this answer key with the official scoring key and rating guide. (Because regional or group scoring is being used by all teachers, teachers should discuss the official key and other possible answers before beginning rating.) This process will give you a valuable "feel" for the questions and indicate potential trouble spots and/or alternative solutions before the rating begins.

3. Teacher discretion is allowed in those situations not covered by the official scoring key and rating guide. However, do not allow any credit for incorrect physics.

4. Do not correct a student's work by making insertions or changes of any kind.

5. Do not make any marks on a Regents answer paper for Parts B-2 and C other than to indicate the number of credits given the student's answers.

6. In scoring Parts B-2 and C, enter the points awarded (0 or 1) for each question under the question number.

7. Accept any equivalent form of the correct answer, unless a specific form is indicated in the question. (This includes use of fractions instead of decimals and the use of "E" or "e" instead of scientific notation, such as "3.00E8" instead of "3.00×10^8.")

8. Allow credit in whole numbers only on Parts B-2 and C; that is, do not allow fractional credit.

9. Be especially careful when rating answers to latter parts of a question that are based on former parts. A seemingly incorrect response may receive credit if it is based on a mistake the student made previously. (This includes using an incorrect answer to a previous question in the substitution of succeeding questions and finding a correct numerical answer based on incorrect substitution or miscopied equation.) The rationale is that students should not be penalized more than once for the same mistake in the same question.

10. In their answers to questions in Parts B-2 and C, students should show all work where indicated.

11. Do not allow or deduct more credit than is allowed for each part of a question.

SPECIFIC RATING CRITERIA

The examples presented and discussed in the following section of this guide contain references to these general suggestions for rating, where appropriate.

Single-Step Calculations

Generally, a calculation is worth a maximum of 2 credits (1,1). Allow the first credit if the student shows the equation and substitution with units into the equation. Allow the second credit if the correct answer is recorded with appropriate units. If students list knowns before their equation and include all units, students need not use units in substitution to receive credit for substitution with units; however units must be included in the answer.

An equation is a relationship between physical quantities. Therefore it includes symbols (not units) that represent quantities.

When rating calculations, review all the student's work to be certain that the physics concepts are applied correctly. At times, a student may make two or more errors that cancel each other out, resulting in a correct answer based on erroneous physics.

Allow 1 credit (0,1) if a student records the equation, substitutes with numbers only, and records the correct answer without units. Penalize a student only once per question for leaving out units. However, allow no credit if another error was made, such as recording an incorrect equation (or no equation) or making a calculation error.

Allow credit (0,1) if a student substitutes incorrectly into the correct equation and follows the calculation through to an appropriate answer based on an incorrect substitution.

Examples:

Since the 2 credits are awarded separately, examples are shown with the following notations:
(1,1); (1,0); (0,1); and (0,0).

Example problem: Calculate the magnitude of the momentum of a 5.0-kilogram object moving at 3.0 meters per second.

Calculations allowed 2 credits (1,1):

- $p = mv$
  $p = (5.0\text{ kg})(3.0\text{ m/s})$
  $p = 15\text{ kg}\bullet\text{m/s}$
  [(1,1) all work correct, answer with units]

- $p = mv$ $\quad m = 5.0\text{ kg}$
  $p = (5)(3)$ $\quad v = 3.0\text{ m/s}$
  $p = 15\text{ kg}\bullet\text{m/s}$
  [(1,1) all work correct, answer with units]

Calculations allowed 1 credit (0,1) or (1,0):

- $p = mv$
  $p = (5.0)(3.0)$
  $p = 15\text{ kg}\bullet\text{m/s}$
  [(0,1) no units in substitution, correct answer with units]

- $p = 15\text{ kg}\bullet\text{m/s}$
  [(0,1) no equation or substitution, correct answer with units]

- p = (4.0 kg)(3.0m/s)
  p = 12 kg•m/s
  [(0,1) no equation, incorrect substitution, appropriate answer with units]

- $p = mv$
  p = (5.0)(3.0)
  p = 15
  [(0,1) no units in substitution and in answer, calculation correct]

- $p = mv$
  p = 15 kg•m/s
  [(0,1) no substitution, correct answer with units]

- $p = mv$
  p = (5.0 kg)(3.0 m/s)
  p = 15
  [(1,0) all work correct, no units in answer]

Calculations allowed no credit (0,0):

- $p = mv$
  p = (5.0)(3.0)
  p = 8 kg•m/s
  [(0,0) no units in substitution, calculations incorrect]

- $p = mv$
  p = (5 kg)(2 m/s)
  p = 10 kg•m/s
  [(0,1) incorrect substitution, appropriate answer with units]

- p = 15
  [(0,0) no equation, no substitution, no units in answer]

- p = (5.0 kg)(3.0 m/s)
  p = 12 kg•m/s
  [(0,0) no equation, incorrect answer]

Allow credit (0,1) if a student copies the appropriate equation incorrectly, but then follows the calculation through to a correct answer based on the incorrect equation.

Examples:

Calculations allowed 1 credit, based on the correct calculations shown above, where p = mv = 15 kg•m/s.

- $p = \frac{1}{2}mv$
  p = ½(5.0 kg)(3.0 m/s)
  p = 15 kg•m/s
  [(0,1) incorrect equation, correct answer with units]

- $p = 2mv$
  p = 2(5 kg)(3 m/s)
  p = 30 kg•m/s
  [(0,1) incorrect equation, appropriate answer with units]

Example problem: Calculate the kinetic energy of a 3.0-kilogram object moving at 4.0 meters per second.

- $KE = \frac{1}{2}mv^2$
  KE = ½(3.0 kg)(4.0 m/s)
  KE = 6.0 J
  [(0,1) incorrect substitution, appropriate answer with units]

- $KE = \frac{1}{2}mv^2$
  KE = ½(3.0 kg)(4.0 m/s)
  KE = 24 J
  [(0,1) incorrect substitution, correct answer with units]

- $KE = \frac{1}{2}mv^2$
  KE = ½(3.0 kg)(4.0 m/s)
  KE = 6.0 kg•m/s
  [(0,1) incorrect substitution, appropriate answer with units]

- $KE = \frac{1}{2}mv^2$
  KE = ½(3.0 kg)(4.0 m/s)
  KE = 24 kg•m/s
  [(0,0) incorrect substitution, incorrect units for calculation]

Example problem: A ray of light passing through air is incident upon a Lucite block at an angle of incidence of 30.°. Calculate the angle of refraction in Lucite.

$n_1 \sin\theta_1 = n_2 \sin\theta_2$
$(1.00)\sin 30. = (1.50)\sin\theta_2$
$\theta_2 = 19°$
[(0,1) no units (°) in substitution, correct answer with units]

Note: The degree symbol is a unit and must be present on angles to receive credit.

Example problem: Calculate the time it takes to travel 10 meters at a constant speed of 2 meters per second.

- $\bar{v} = \dfrac{d}{t}$

  $t = \dfrac{d}{v}$

  $t = \dfrac{10\ \text{m}}{2\ \text{m/s}}$

  $t = 5\ \text{s}$

  [(1,1)]

- $t = \dfrac{\bar{v}}{d}$

  $t = \dfrac{2\ \text{m/s}}{10\ \text{m}}$

  $t = 5\ \text{s}$

  [(0,1) incorrect equation; correct answer]

- $\bar{v} = \dfrac{d}{t}$

  $t = \dfrac{2\ \text{m/s}}{10\ \text{m}}$

  $t = 0.2\ \text{s}$

  [(0,1) incorrect substitution, appropriate answer based on substitution]

- $t = \dfrac{\bar{v}}{d}$

  $t = \dfrac{2\ \text{m/s}}{10\ \text{m}}$

  $t = 0.2\ \text{s}^{-1}$

  [(0,1) incorrect equation; appropriate answer based on substitution]

Example problem: Calculate the power dissipated by a 24-ohm resistor connected to a 12-volt battery.

- $P = \dfrac{V^2}{R}$

  $P = \dfrac{(12\ V)^2}{24\ \Omega}$

  $P = 6\ \text{W}$

  [(1,1)]

- $P = \dfrac{V^2}{R}$

  $P = \dfrac{12\ V^2}{24\ \Omega}$

  $P = 6\ \text{W}$

  [(1,1) parentheses not shown, but calculation indicates their presence]

- $P = \dfrac{V^2}{R}$

  $P = \dfrac{12\ V^2}{24\ \Omega}$

  $P = 0.50\ \text{W}$

  [(1,0) calculation indicates the parentheses are not present]

Expressing Numerical Answers

Do not penalize students for not using significant figures. Allow credit even if a student has rounding errors or truncation errors. If 3.247 is the correct answer, then 3.24; 3.25; 3.2; 3.3; and 3 would all receive credit.

Scientific notation - The preferred form for expressing a value using scientific notation is 3.00×10^8, but alternatives are acceptable:

3.00×10^8 = 3.00E8 = 3.00e8

Multistep Calculations

Often calculations may be performed using equations and/or solution strategies other than those provided in the scoring key and rating guide. In such cases, allow full credit if the physics and the solution are correct. To ensure that students receive maximum credit, raters should concentrate on the last step of the calculation by applying the rules for rating a single step calculation.

Example problem: Calculate the speed of a 2.0-kilogram object, initially at rest, after it has fallen freely 10. meters.

$\Delta PE = mg\Delta \text{h}$
$\Delta PE = (2.0)(9.81)(10.\text{m})$
$\Delta PE = 98.1 \text{ J}$

$KE = \frac{1}{2}mv^2$
$98.1 \text{ J} = \frac{1}{2}(2.0 \text{ kg})v^2$
$v = 9.9 \text{ m/s}$

The student attempts a multistep calculation. The first calculation is missing units and is incorrect. Only the last step is rated. As a result, 1 credit is allowed. [(0,1) incorrect substitution, appropriate answer with correct units]

Use of Different Symbols and Equations

Since texts use various symbols for physical quantities, students may write equations with different symbols than those on the *Reference Tables for Physical Setting/Physics* and still receive credit for the equation. Example: $\Delta s = v_i t + \frac{1}{2}at^2$ (Δs = displacement).

A student may use an equation not on the *Reference Tables for Physical Setting/Physics*. If this equation is valid for solving the problem, the student should receive credit. For example, a student uses $E = \frac{V}{d}$ to find the electric field strength between two parallel, oppositely charged plates. This is a valid equation and the student should be given credit.

Use of Units

The SI (International System) units are used in the Physical Setting/Physics Core Curriculum and in the Regents examinations. However, students are expected to have an understanding of metric units. Where more appropriate, cgs units will be used. Although students are generally expected to record answers in the correct SI unit, also allow credit for the use of correct non-SI units.

Examples:

Hertz (Hz) is the accepted SI unit for frequency, but cycles per second (cps) is equivalent and acceptable.

f = 10 Hz; allow full credit; units are SI
f = 10 cps; allow full credit; units are equivalent to Hz
f = 10 s^{-1}; allow full credit; units are equivalent to Hz

Often when large distances are expressed, the use of kilometers is conceptually more appropriate than the use of meters. Similarly, expressing a small mass as 2 grams may have more meaning for the student than 0.002 kilogram. Allow credit for these equivalent answers unless the unit is specified in the question.

Example:

d = 50 km; allow full credit for 50 km, even though 50 000 m expresses the answer in the correct SI unit.

Graphs

To receive full credit for constructing a graph, the student must be able to:

1. label both axes with appropriate variables and units
2. mark linear scales with appropriate scale divisions
3. plot all points accurately
4. draw a best-fit line
5. calculate the slope of the best fit line at a point

Requirements vary according to the graphing questions. A partially completed graph may be provided for the student to finish according to directions given in the question(s).

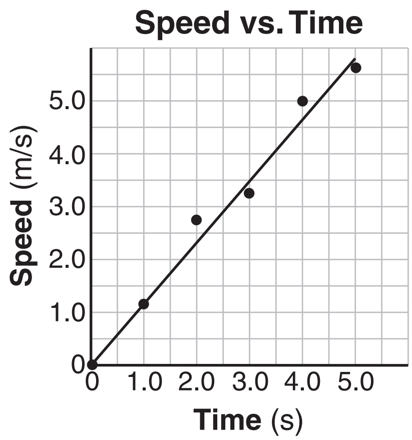
1. Axes: By convention, the dependent variable should be placed on the y-axis. However, do not penalize students for not following this convention on graphs constructed for the Regents Examination in Physical Setting/Physics. A graph constructed without following this convention is not wrong; at times the data being analyzed are better presented by placing the dependent variable on the x-axis.

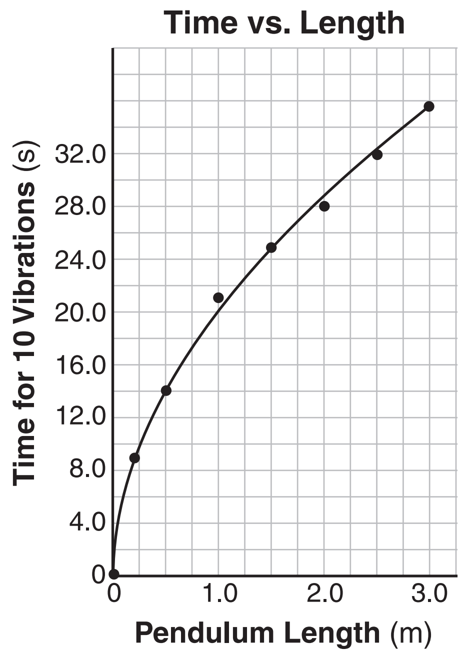
2. Scales: When a question requires students to develop the scale for one or both axes, they are expected to select appropriate scale divisions. The term "appropriate" means that most (not necessarily all) of the grid provided is used and that scale divisions allow for relatively simple estimation between lines.

3. Points: All data points should be plotted within +/-0.3 grid space of their true positions. Single points are clearest, but points emphasized with circles or crosses are acceptable. Do not allow credit for points or empty circles drawn larger than 0.3 grid space in diameter.

4. Best-fit line: When the best-fit line is a straight line, students must draw it with a straightedge. When the best-fit line is a curve, students should draw it as accurately as possible, and the teacher must understand that they will be doing so freehand. A best-fit line should be continuous and have the data points distributed evenly around it if they do not fall exactly upon it. It may or may not pass through the origin, depending on the distribution of points, and it need not pass through the first and last data points on the graph. Students should not merely connect the dots, whether with straight or curved line segments.

Examples of appropriate best fit line and curve:





5. Slope of a graph: To find the slope of a straight line graph, the student must pick two points on the best-fit line and use an appropriate formula (e.g. $m = \Delta y/\Delta x$ or $a = \Delta v/\Delta t$) to determine the value, with units, of the slope. Values taken from the data table may be used only if the student's best-fit line passes through those data points. Credit for the slope calculation should be allowed according to the *Scoring Criteria for Calculations* that appear in the rating guide.

   To find the slope of a curve at a particular point, the student should draw the tangent to the curve at that point and determine the slope of the tangent line as described above for a straight line. The use of analysis (e.g., derivative of a function) may not be used to determine a slope unless the graph was derived from a specific function or is shown by the student to be derived from that function. Generally, graphs drawn from experimental data should not be assumed to represent any particular mathematical function. Students should be able to determine the physical quantity represented by the slope of a graph, i.e. acceleration for a speed versus time graph or speed for a distance versus time graph.

6. Area under a curve: Students should be able to calculate the area under a line or curve and identify the physical quantity represented by the area under lines or curves, i.e. distance is represented by the area under a speed versus time graph.

7. Generally, a graph should have a title. Students may be required to provide a title for a graph constructed for the Regents examination in Physical Setting/Physics. However, if no title is required in the question, credit should not be deducted if it is missing.

Ray Diagrams

Only one arrowhead is needed in a ray diagram to determine the direction of all the rays in a ray diagram. Therefore, students do not need to place arrowheads on rays to receive credit for the diagram unless specified in the question.

Vector Diagrams

Each vector must have an arrowhead pointing in the correct direction. The length of each vector is from the tail of the arrow to the tip of the arrowhead. The length of the vector must be the correct scaled length for a student to receive credit for a vector diagram.

Allow credit for a student drawn vector even when it does not begin or end at a given point as long as it is the correct scaled length and pointing in the correct direction.

Drawing of Wave Forms

When a student is asked to draw a wave of given amplitude and wavelength, the student is asked to draw at least one wavelength. If the student were to draw more than one wavelength, the first wavelength is to be graded and the rest of the diagram ignored.

Allow credit for the amplitude of a wave if both the maximum positive and maximum negative displacements are within ¼ of a grid space of the intended amplitude.

Allow credit for the wavelength if the drawn wavelength is within ¼ of a grid space of the intended wavelength.

Orders of Magnitude

The order of magnitude of a number is the nearest power of 10 of the number when in correct scientific notation. It should be noted that this is a log scale and the cutoff is the square root of 10 (3.16), not 5.

TEACHER DISCRETION

Teacher discretion is permitted, provided students are not allowed credit for incorrect physics.

It is not possible to anticipate all possible rating questions and each teacher's individual rating practices. As a result, you may encounter student solutions to questions not discussed in the scoring key and rating guide. When this situation occurs, you have the discretion to determine what credit should be allowed, but only if credit is not allowed for errors in physics. Teachers rating student responses through regional or group scoring should reach consensus on acceptable answers that are not addressed in the scoring key and rating guide.