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Multiple-Choice Answer Key

The following contains the answers to
the multiple-choice questions in this exam.

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Answer Key for AP Physics 2 Practice Exam, Section I

Question 1: D
Question 2: B
Question 3: C
Question 4: D
Question 5: B
Question 6: C
Question 7: B
Question 8: D
Question 9: D
Question 10: A
Question 11: C
Question 12: C
Question 13: D
Question 14: C
Question 15: D
Question 16: A
Question 17: C
Question 18: C
Question 19: C
Question 20: D
Question 21: C
Question 22: B
Question 23: D
Question 24: A
Question 25: D
Question 26: C
Question 27: D
Question 28: D
Question 29: D
Question 30: B
Question 31: D
Question 32: A
Question 33: D
Question 34: B
Question 35: C
Question 36: A
Question 131: B, C
Question 132: A, D
Question 133: A, C
Question 134: A, C

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Free-Response Scoring Guidelines

The following contains the scoring guidelines
for the free-response questions in this exam.

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AP® PHYSICS 2
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Question 1

10 points total | **Distribution of points**

(a) 5 points

For indicating that a floating object displaces its weight in water — 1 point
For indicating that a submerged object displaces its volume in water — 1 point
For justifying with correct reasoning that the volume of displaced water required to make the cube float is much greater than the cube's volume — 1 point
Examples: Noting that the density of the block is much greater than that of water; noting that when the cube is on the bottom the buoyant force is less than the weight because of the normal force
For predicting that the water level is lower when the block is submerged (or higher when the block is floating) given some attempt to explain the concepts listed above — 1 point
For a logical, relevant, and internally consistent response that addresses the required argument or question asked, and follows the guidelines described in the published requirements for the paragraph-length response — 1 point

(b)

i) 1 point

For indicating that the tension is the same at any depth with a correct reference to the buoyant force — 1 point
Example: The volume of water displaced remains the same so the buoyant force remains the same. The weight of the cube does not change, so the force exerted by the crane is unchanged.

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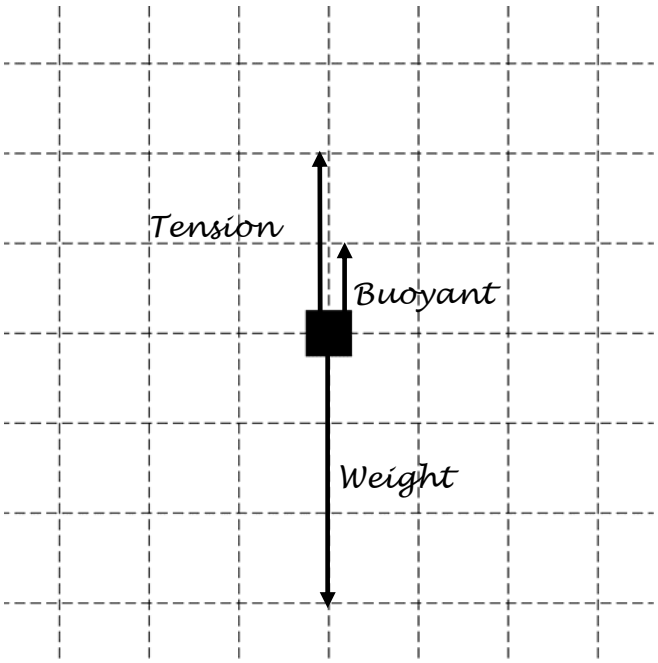
Question 1 (continued)

Distribution of points

ii) 2 points



For a labeled buoyant force directed upward and a labeled gravitational force directed downward, with the buoyant force drawn shorter than the gravitational force — 1 point

For a labeled tension force directed upward and the sum of the drawn vectors approximately indicating equilibrium — 1 point

Figure can have a single buoyant force, or a set of pressure forces that reasonably equals an appropriate net buoyant force, but not both.

Only force vectors that clearly originate on the block earn credit.

iii) 2 points

For an expression obtained by using Newton's 2nd law for equilibrium and the free body diagram in part (b)(ii) — 1 point

$F_{Tension} = F_g - F_b$

$F_{Tension} = m_{cube}g - \rho g V_{cube}$

For correct substitutions into the buoyant force and the gravitational force expressions or a numerical answer implying correct substitutions of the given quantities — 1 point

$F_{Tension} = (730\ \text{kg})\left(9.8\ \text{m/s}^2\right) - \left(1000\ \text{kg/m}^3\right)\left(9.8\ \text{m/s}^2\right)(0.45\ \text{m})^3$

$F_{Tension} = 6300\ \text{N}$ (or 6400 N using $g = 10\ \text{m/s}^2$)

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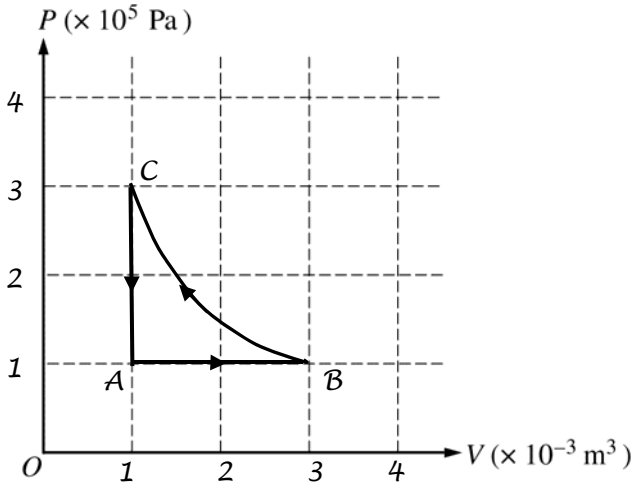
Question 2

12 points total **Distribution of points**

(a)

i) 3 points



For a straight line at constant pressure from A to B to the correct final volume, which must be labeled 3 — 1 point

For an isotherm from B to C ending at the right final pressure, which must be labeled 3; curve must be obviously concave up — 1 point

For a straight line from C to A at constant volume, with state A labeled (1, 1) — 1 point

ii) 1 point

Using the ideal gas law:

$P_A V_A = nRT_0$

$P_B V_B = P_A 3V_A$

$nRT_B = 3nRT_0$

For the correct answer — 1 point

$T_B = 3T_0$

iii) 1 point

For a correct comparison of the temperatures <u>or</u> correctly indicating — 1 point

$T_B = T_C = 3T_A$ or $3T_0$ or a value consistent with the answer to part (a)(i) or (ii)

<u>AND</u> making a reference to the isotherm <u>or</u> the values of P and V at points C and A

Examples:

$T_C = 3T_0$ since it is on an isotherm with point B, as shown by the graph.

On the graph, C has the same volume and 3 times the pressure as A. By the ideal gas law it thus has a temperature 3 times that of A.

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Question 2 (continued)

Distribution of points

(b)

i) 2 points

For recognizing that the volume remains constant and describing a valid way to accomplish this in the procedure — 1 point

For recognizing that the temperature must decrease and describing a valid way to accomplish this in the procedure — 1 point

Example: Lock the piston in place and put the cylinder in a cool water bath.

ii) 2 points

For some reasonable description of microscopic processes in which collision of molecules is the process by which energy is transferred — 1 point

For correctly stating the direction of energy flow (e.g. hot (fast) to cold (slow)) and linking the direction of energy flow to the final temperature of the gas — 1 point

Example: The warmer gas (faster molecules) collide with the cooler surroundings (slower molecules). The net energy flow is from the gas to the surroundings which results in cooler gas (slower molecules).

(c)

i) 2 points

For numerically calculating the amount of work done $\left(W = \left|P\Delta V\right|\right)$ — 1 point

$W = -P\Delta V = -\left(1 \times 10^5 \text{ Pa}\right)\left(2 \times 10^{-3} \text{ m}^3\right)$

For the correct answer with negative sign (no units required) — 1 point

$W = -200 \text{ J}$

ii) 1 point

For applying conservation of energy using the value from part (c)(i) — 1 point

$\Delta U = Q + W$

$300 \text{ J} = Q - 200 \text{ J}$

$Q = 500 \text{ J}$

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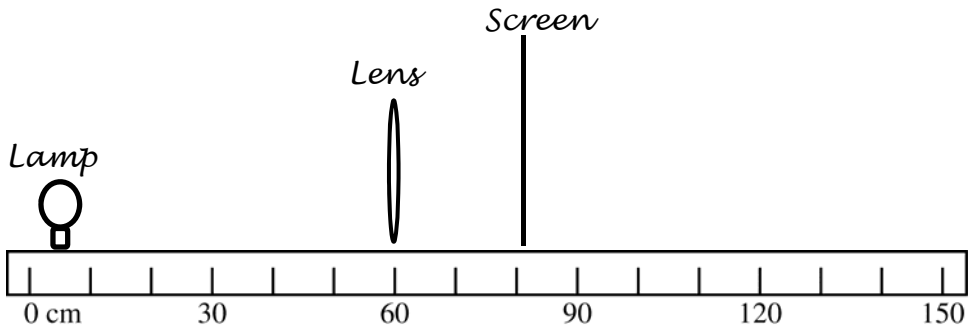
Question 3

12 points total **Distribution of points**

(a) 2 points



For the lamp correctly positioned 55 cm from the converging lens 1 point
For the screen correctly positioned 21.3 cm from the lens, on the opposite side from the lamp 1 point

(b) 3 points

For indicating a valid pair of quantities that would lead to a linear graph from which the focal length could be determined 1 point
For justifying the choice of quantities, either by indicating how to use the slope or intercept of the line to determine the focal length or by indicating how the lens equation yields a linear function 1 point
For calculating data for the table, with at least three correct pairs of numbers 1 point
Table below shows data for two possibilities: $1/s_0$ and $1/s_i$; $s_0 s_i$ and $s_0 + s_i$

Trial	1	2	3	4	5
Object Distance s_o (cm)	55	45	35	30	25
Image Distance s_i (cm)	21.3	23.8	28.5	32.5	43
$1/s_O$	0.018	0.022	0.029	0.033	0.04
$1/s_i$	0.047	0.042	0.035	0.031	0.023
$s_O s_i$	1172	1071	998	975	1075
$s_O + s_i$	76	69	64	63	68

(c)

i) 2 points

For the axes scaled linearly and labeled with units for plotted quantities (even if the wrong quantities are plotted), such that the plot uses at least half of the axes 1 point
For correctly plotting the data listed in the part (b) table 1 point
The following graphs show the two possibilities noted above.

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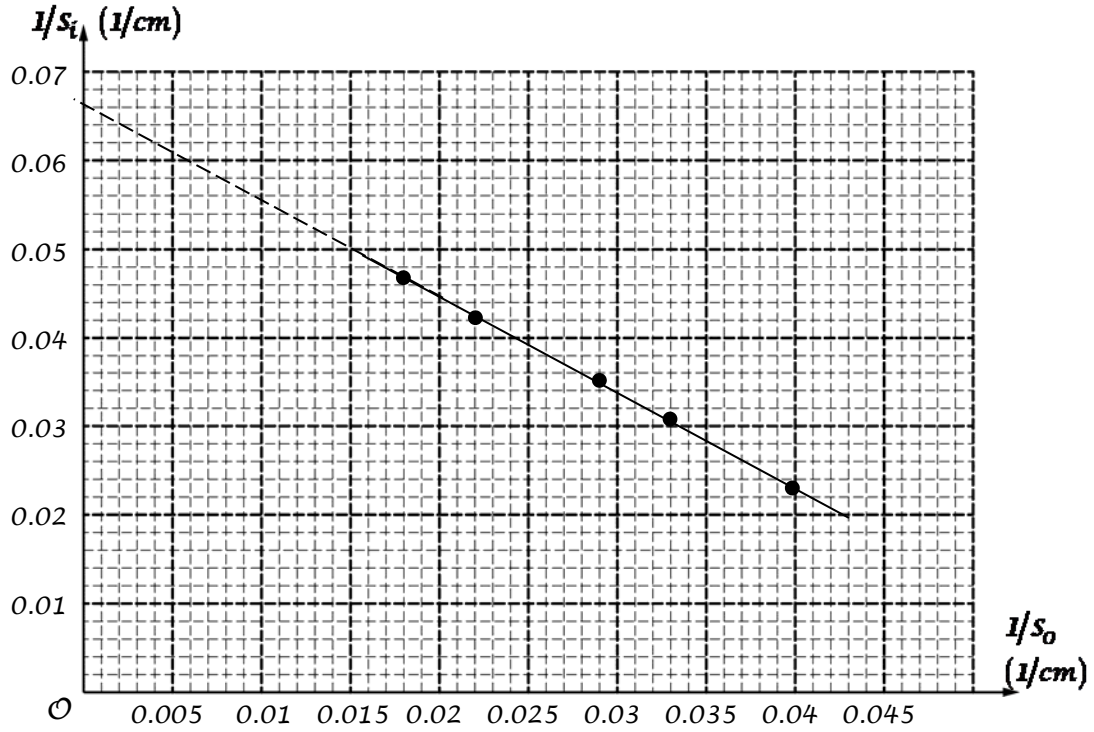
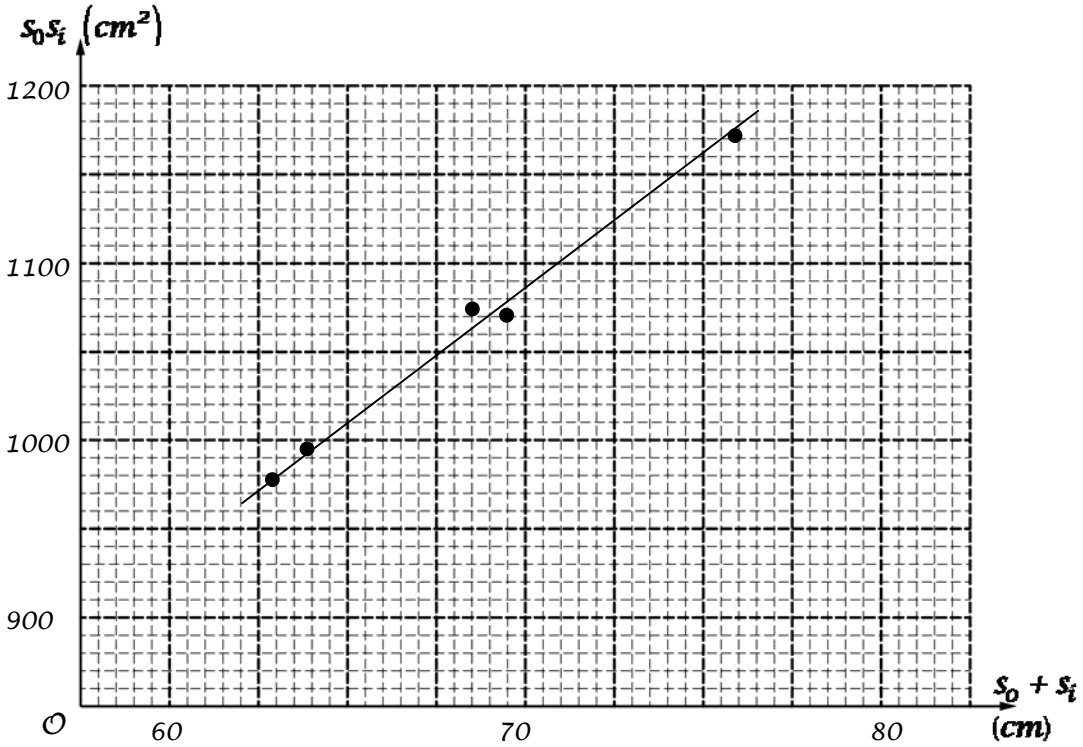
Question 3 (continued)

Distribution of points

(c) i) (continued)





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Question 3 (continued)

Distribution of points

(c) (continued)

ii) 2 points

For drawing a straight best-fit line accurately through the data (data points evenly distributed about the line and representing the trend of the data) — 1 point

For accurately calculating the slope or intercept using the graph (depending on quantities plotted) and relating it to the focal length — 1 point

For the first graph ($1/s_i$ as a function of $1/s_0$):

From the lens equation $\frac{1}{s_i} = \frac{1}{f} - \frac{1}{s_0}$, so $\frac{1}{f}$ equals the intercept on the $1/s_i$ axis

$\frac{1}{f} = 0.066 \text{ cm}^{-1}$

$f = 15.2 \text{ cm}$

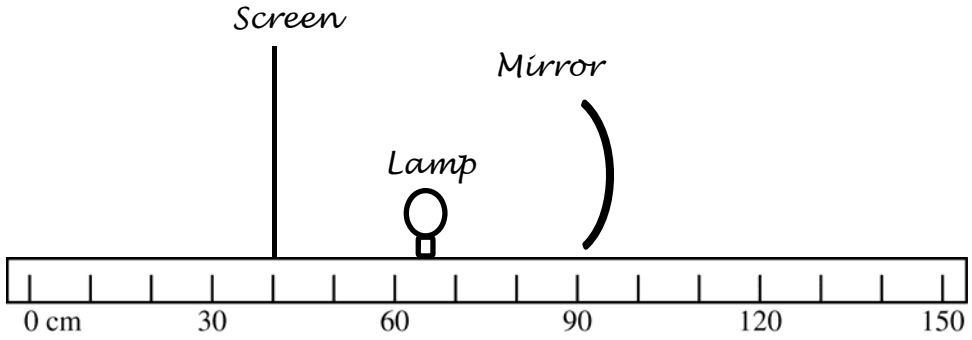
For the second graph ($s_0 s_i$ as a function of $s_0 + s_i$):

The lens equation can be rearranged as $s_0 s_i = f(s_0 + s_i)$, so f equals the slope

$f = \frac{(1170 - 970) \text{ cm}^2}{(75.5 - 62.5) \text{ cm}} = \frac{200}{13} \text{ cm}$

$f = 15.4 \text{ cm}$

(d) 3 points



For drawing and labeling the lamp, screen, and converging mirror at positions that will create a real image — 1 point

For describing appropriate measurements — 1 point

For describing a calculation of the focal length that correctly uses the measurements — 1 point

Example: Place the lamp between 15 and 30 cm from the mirror. Place the screen on the other side of the lamp from the mirror, adjusting its position until the clearest image is formed. Measure the distance of the lamp and screen from the mirror. Use the equation $\frac{1}{s_i} + \frac{1}{s_0} = \frac{1}{f}$ to calculate the focal length.

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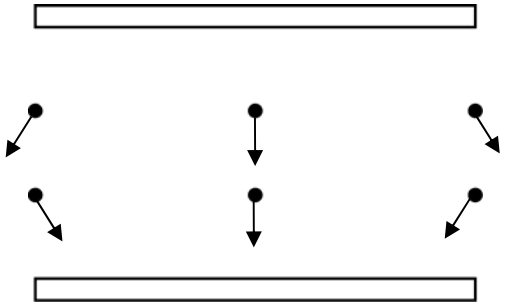
Question 4

10 points total **Distribution of points**

(a)

i) 2 points



For a representation of the electric field using vectors (not curved lines) that each have a component downward — 1 point

For accurately representing fringing near the edges and a uniform field near the middle (even if field lines are drawn instead of vectors, or the field has components upward instead of downward) — 1 point

ii) 1 point

For a correct calculation of the charge — 1 point

$Q = C\,\Delta V = \left(\varepsilon_0 L^2 / d_2\right) V_0$

$Q = \varepsilon_0 L^2 V_0 / d_2$

(b)

i) 2 points

For indicating that since the battery remains connected, the potential difference across the capacitor remains the same — 1 point

For indicating that the electric field must decrease since $E = \Delta V / d$ and d has increased — 1 point

Alternate Solution — *Alternate points*

$C = \kappa \varepsilon_0 A / d$

For reasoning that capacitance decreases as d increases — *1 point*

$Q = C\,\Delta V$

For reasoning that the potential difference across the capacitor remains the same and therefore the charge decreases — *1 point*

$E = Q / \varepsilon_0 A$, *so E decreases because Q decreases*

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Question 4 (continued)

Distribution of points

(b) (continued)

ii) 2 points

For indicating that the charge on each plate is the same as in part (a)(ii) — 1 point
For reasoning that the electric field depends only on the magnitude of the charge, and therefore does not change (or has a change consistent with the change in charge indicated) — 1 point

Examples:

The charge on the plates does not change, so E remains the same.

$E = \Delta V/d = Q/Cd$. Since $C \propto 1/d$, E is independent of the plate spacing which is the only thing that changes.

Alternate Solution — *Alternate points*

$C = \kappa\varepsilon_0 A/d$, *so as d increases C decreases*

$\Delta V = Q/C$

For recognizing that since charge is constant, as C decreases ΔV *increases* — *1 point*

$E = \Delta V/d$

For reasoning that E does not change since ΔV *and d increase by the same factor* — *1 point*

(c) 3 points

For indicating that the potential difference is the same across each capacitor — 1 point
For indicating that $C_2 = 4C_1$ — 1 point
For values of the charge on each capacitor consistent with the relationship between capacitances — 1 point

$Q_1 = Q_0$, $Q_2 = 4Q_0$

Example: The conditions for C_1 are the same as in part (a)(ii), so it has a charge Q_0. The area of C_2 is four times that of C_1, so it has four times the capacitance. In order to have the same potential difference as C_1, it must therefore have four times the charge.

Alternate solution — *Alternate Points*

For indicating the potential difference is the same across each capacitor — *1 point*

For indicating $A_2 = 4A_1$ — *1 point*

For values of the charge on each capacitor consistent with the relationship between areas — *1 point*

$Q_1 = \varepsilon_0 V_0 L^2/d_2$

$Q_2 = \varepsilon_0 V_0 (2L)^2/d_2$

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Scoring Worksheet

The following provides a scoring worksheet and conversion table used for calculating a composite score of the exam.

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2017 AP Physics 2 Scoring Worksheet

Section I: Multiple Choice

_____ × 1.0000 = _____
Number Correct (out of 40) | Weighted Section I Score (Do not round)

Section II: Free Response

Question 1 _____ × 0.9090 = _____
(out of 10) (Do not round)

Question 2 _____ × 0.9090 = _____
(out of 12) (Do not round)

Question 3 _____ × 0.9090 = _____
(out of 12) (Do not round)

Question 4 _____ × 0.9090 = _____
(out of 10) (Do not round)

Sum = _____
Weighted Section II Score (Do not round)

Composite Score

_____ + _____ = _____
Weighted Section I Score | Weighted Section II Score | Composite Score (Round to nearest whole number)

AP Score Conversion Chart
Physics 2

Composite Score Range	AP Score
57-80	5
48-56	4
34-47	3
20-33	2
0-19	1

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Question Descriptors and Performance Data

The following contains tables showing the content assessed,
the correct answer, and how AP students performed on each question.

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Multiple-Choice Questions

Question	Learning Objectives	Essential Knowledge	Science Practices	Key	% Correct
1	2-7.C.1.1	7.C.1	1.4	D	94
2	2-6.A.1.2	6.A.1	1.2	B	84
3	2-3.C.2.2|2-3.G.1.2	3.C.2|3.G.1	7.2|7.1	C	82
4	2-1.A.4.1|2-5.B.8.1|2-7.C.4.1	1.A.4|5.B.8|7.C.4	1.1|1.2|1.1|1.2	D	65
5	2-2.D.3.1	2.D.3	1.2	B	75
6	2-4.E.3.4	4.E.3	1.1|1.4|6.4	C	75
7	2-2.C.5.3	2.C.5	1.1|7.1	B	74
8	2-5.B.9.5|2-5.B.9.6	5.B.9	6.4|2.2	D	70
9	2-3.B.1.4|2-3.C.3.1|2-4.E.2.1	3.B.1|3.C.3|4.E.2	6.4|7.2|1.4|6.4	D	18
10	2-5.B.7.3	5.B.7	1.4|2.2	A	60
11	2-5.B.6.1	5.B.6	1.2	C	52
12	2-5.B.7.1|2-5.B.7.3	5.B.7	6.4|1.4|2.2	C	58
13	2-6.C.1.2|2-6.C.1.1	6.C.1	6.4|1.4	D	69
14	2-4.E.5.3|2-5.B.9.4|2-5.B.9.7	4.E.5|5.B.9	5.1|5.1|5.1	C	38
15	2-4.E.5.2|2-4.E.5.3	4.E.5	6.4|5.1	D	39
16	2-5.B.4.1|2-7.A.2.1	5.B.4|7.A.2	6.4|7.2|7.1	A	55
17	2-5.D.2.6	5.D.2	6.4|7.2	C	45
18	2-4.C.4.1	4.C.4	2.2|7.2	C	58
19	2-7.C.3.1	7.C.3	6.4	C	41
20	2-6.E.5.1	6.E.5	1.4|2.2	D	65
21	2-2.C.2.1|2-2.E.2.1	2.C.2|2.E.2	2.2|6.4|6.4	C	41
22	2-2.C.1.2|2-2.E.3.1|2-2.E.3.2|2-5.B.5.5	2.C.1|2.E.3|5.B.5	2.2|2.2|1.4|6.4|2.2|6.4	B	56
23	2-3.C.2.3	3.C.2	2.2	D	56
24	2-7.A.3.1|2-7.A.3.3	7.A.3	6.4|7.2|5.1	A	59
25	2-4.E.3.3	4.E.3	1.1	D	49
26	2-1.E.3.1	1.E.3	5.1	C	49
27	2-7.A.1.2	7.A.1	1.4|2.2	D	52
28	2-5.F.1.1	5.F.1	2.2	D	71
29	2-3.C.4.2	3.C.4	6.2	D	65
30	2-6.F.1.1|2-6.F.2.1	6.F.1|6.F.2	6.4|7.2|1.1	B	49
31	2-4.E.5.1	4.E.5	2.2|6.4	D	40
32	2-7.A.2.2	7.A.2	7.1	A	54
33	2-3.C.3.1	3.C.3	1.4	D	47
34	2-2.C.1.1	2.C.1	6.4	B	37
35	2-5.B.9.5	5.B.9	6.4	C	36
36	2-6.G.1.1	6.G.1	6.4|7.1	A	31

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Question	Learning Objectives	Essential Knowledge	Science Practices	Key	% Correct
131	2-7.A.3.2	7.A.3	4.2	B,C	88
132	2-6.E.2.1|2-6.E.4.1	6.E.2|6.E.4	6.4|4.1|5.1	A,D	70
133	2-6.E.3.3	6.E.3	6.4	A,C	54
134	2-5.B.10.4	5.B.10	6.2	A,C	50

Free-Response Questions

Question	Learning Objectives	Essential Knowledge	Science Practices	Mean Score
1	2-1.E.1.2|2-3.B.1.4|2-3.B.2.1|2-3.C.4.1|2-5.B.10.1|2-5.B.10.2	1.E.1|3.B.1|3.B.2|3.C.4|5.B.10	6.4|6.4|1.1|2.2|6.1|2.2|2.2	4.05
2	2-4.C.3.1|2-5.B.4.1|2-5.B.5.6|2-5.B.6.1|2-5.B.7.1|2-5.B.7.2|2-5.B.7.3|2-7.A.2.2|2-7.A.3.3	4.C.3|5.B.4|5.B.5|5.B.6|5.B.7|7.A.2|7.A.3	6.4|6.4|7.2|5.1|1.2|6.4|1.1|1.4|2.2|7.1|5.1	6.86
3	2-6.E.4.1|2-6.E.5.2	6.E.4|6.E.5	4.1|5.2|4.1|5.1	4.86
4	2-2.C.5.1|2-2.C.5.2|2-4.E.4.1|2-4.E.5.1|2-4.E.5.2	2.C.5|2.C.5|4.E.4|4.E.5	1.1|2.2|2.2|6.4|6.4|6.4	2.43

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AP Physics 2: Algebra-Based

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