AP® PHYSICS B (Form B)
2008 SCORING GUIDELINES

General Notes About 2008 AP Physics Scoring Guidelines

1. The solutions contain the most common method of solving the free-response questions and the allocation of points for this solution. Some also contain a common alternate solution. Other methods of solution also receive appropriate credit for correct work.

2. Generally, double penalty for errors is avoided. For example, if an incorrect answer to part (a) is correctly substituted into an otherwise correct solution to part (b), full credit will usually be awarded. One exception to this may be cases when the numerical answer to a later part should be easily recognized as wrong, e.g., a speed faster than the speed of light in vacuum.

3. Implicit statements of concepts normally receive credit. For example, if use of the equation expressing a particular concept is worth 1 point and a student's solution contains the application of that equation to the problem, but the student does not write the basic equation, the point is still awarded. However, when students are asked to derive an expression, it is normally expected that they will begin by writing one or more fundamental equations such as those given on the AP Physics Exam equation sheet. For a description of the use of such terms as "derive" and "calculate" on the exams, and what is expected for each, see "The Free-Response Sections—Student Presentation" in the *AP Physics Course Description*.

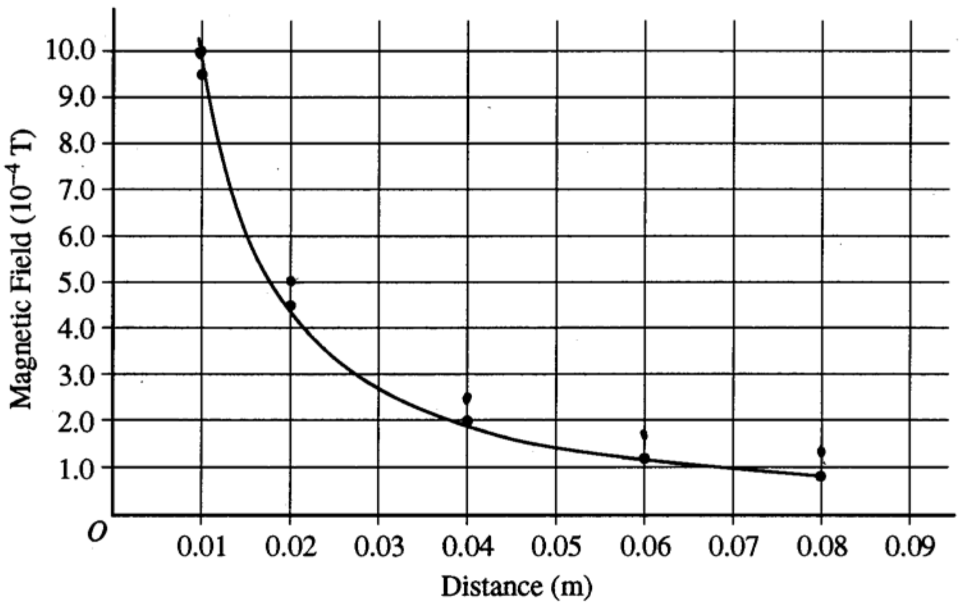
4. The scoring guidelines typically show numerical results using the value $g = 9.8\ \text{m/s}^2$, but use of $10\ \text{m/s}^2$ is, of course, also acceptable. Solutions usually show numerical answers using both values when they are significantly different.

5. Strict rules regarding significant digits are usually not applied to numerical answers. However, in some cases, answers containing too many digits may be penalized. In general, two to four significant digits are acceptable. Numerical answers that differ from the published answer due to differences in rounding throughout the question typically receive full credit. Exceptions to these guidelines usually occur when rounding makes a difference in obtaining a reasonable answer. For example, suppose a solution requires subtracting two numbers that should have five significant figures and that differ starting with the fourth digit (e.g., 20.295 and 20.278). Rounding to three digits will lose the accuracy required to determine the difference in the numbers, and some credit may be lost.

Question 3

15 points total **Distribution of points**

(a) 2 points



For each new point being above one of the points shown on the graph — 1 point

For each new point being about the same distance from the old point, a distance equal to one-half the distance between the horizontal grid lines shown — 1 point

(b) 3 points

For an attempted application of a correct relationship to find the current I — 1 point

$$B = \frac{\mu_0}{2\pi}\frac{I}{r}$$

$$I = \frac{2\pi r B}{\mu_0}$$

For correct substitutions using one of the new data points plotted in part (a), for example, using the point $(0.01 \text{ m}, \ 10.0 \times 10^{-4} \text{ T})$ — 1 point

$$I = \frac{2\pi(0.01 \text{ m})(10.0 \times 10^{-4} \text{ T})}{4\pi \times 10^{-7} \ (\text{T}\bullet\text{m})/\text{A}}$$

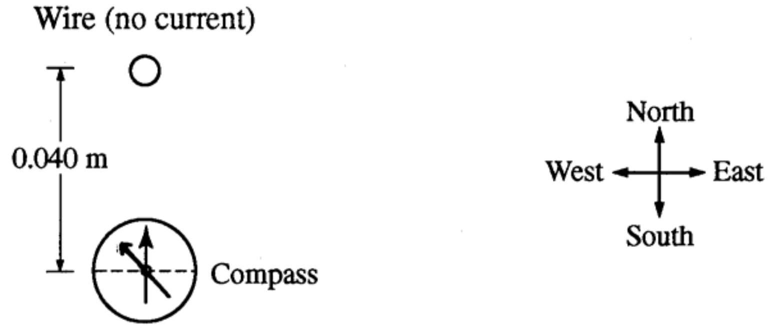
For the correct answer — 1 point

$I = 50$ A

Question 3 (continued)

Distribution of points

(c) 2 points



Note: Figure not drawn to scale.

For the direction that the needle points being toward the northwest quadrant — 2 points

Note: If the needle was drawn pointing directly to the west, 1 point was awarded. If the needle was drawn pointing directly to the north, no points were awarded.

(d) 4 points

For a correct relationship to find the westward component of **B**, and a correct substitution of the current determined in part (b) — 1 point

$$B_w = \frac{\mu_0}{2\pi}\frac{I}{r} = \left(\frac{4\pi \times 10^{-7}\ (\text{T}\bullet\text{m})/\text{A}}{2\pi}\right)\left(\frac{35\ \text{A}}{0.040\ \text{m}}\right)$$

For the correct answer for B_w — 1 point

$$B_w = 17.5 \times 10^{-5}\ \text{T}$$

For a correct relationship relating the northward and westward components to the angle — 1 point

$$\tan\theta = \frac{B_w}{B_n} = \frac{17.5 \times 10^{-5}\ \text{T}}{5.0 \times 10^{-5}\ \text{T}} = 3.5$$

For the correct answer — 1 point

$\theta = 74^\circ$ or 1.3 rad

(e) 2 points

For correct substitution of both values into Ohm's law — 1 point

$\mathcal{E} = IR$

$$R = \frac{\mathcal{E}}{I} = \frac{120\ \text{V}}{35\ \text{A}}$$

For the correct answer including units — 1 point

$R = 3.4\ \Omega$

Question 3 (continued)

Distribution of points

(f) 2 points

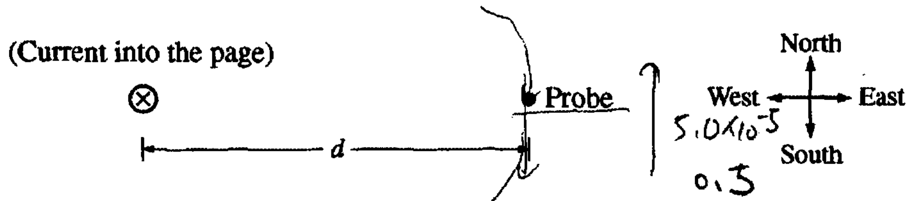
For correct substitution of values into a correct expression for power — 1 point

$P = IV$ (or $P = I^2R$ or $P = V^2/R$)

$P = (35\text{ A})(120\text{ V})$

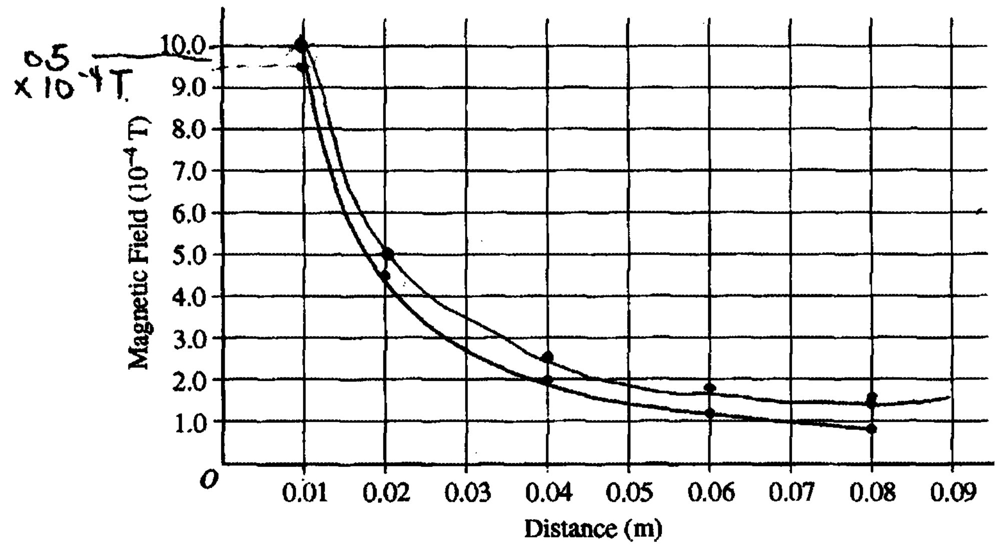
For the correct answer including units — 1 point

$P = 4200\text{ W}$



3. (15 points)

A student is measuring the magnetic field generated by a long, straight wire carrying a constant current. A magnetic field probe is held at various distances d from the wire, as shown above, and the magnetic field is measured. The graph below shows the five data points the student measured and a best-fit curve for the data. Unfortunately, the student forgot about Earth's magnetic field, which has a value of 5.0×10^{-5} T at this location and is directed north.



(a) On the graph, plot new points for the field due only to the wire.

(b) Calculate the value of the current in the wire.

$$B = \frac{\mu_0 I}{2\pi r} = \frac{\mu_0 I}{2\pi \times 0.01 m} = 10 \times 10^{-3} T$$

$$\mu_{air} \simeq \mu_0 = 4\pi \times 10^{-7} (T \cdot m/A)$$

$$\frac{(4\pi \times 10^{-7}) \times I}{2\pi \times 0.01 m} = 2 \times 10^{-5} \times I = 1.0 \times 10^{-3}$$

$$I = \frac{1.0 \times 10^{-3}}{2 \times 10^{-5}}$$

$$I = 50 A$$

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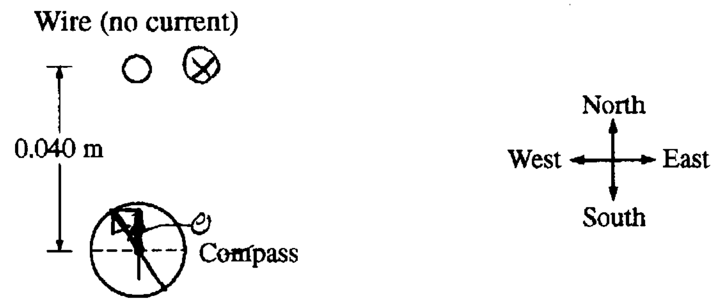
B3A 2

Another student, who does not have a magnetic field probe, uses a compass and the known value of Earth's magnetic field to determine the magnetic field generated by the wire. With the current turned off, the student places the compass 0.040 m from the wire, and the compass points directly toward the wire as shown below. The student then turns on a 35 A current directed into the page.



Note: Figure not drawn to scale.

(c) On the compass, sketch the general direction the needle points after the current is established.

(d) Calculate how many degrees the compass needle rotates from its initial position pointing directly north.

$$\tan\theta = \frac{B}{5.0\times10^{-5}\ T}$$

$$B_I = \frac{4\pi\times10^{-7}\times 35}{2\pi\cdot 0.04} = 1.75\times10^{-4}\ T$$

$$\tan\theta = \frac{1.75\times10^{-4}}{5.0\times10^{-5}} = \boxed{74.05^\circ}$$

The wire is part of a circuit containing a power source with an emf of 120 V and negligible internal resistance.

(e) Calculate the total resistance of the circuit.

$$120V = 35A\cdot R \qquad R = \frac{120V}{35A} \approx 3.43\ \Omega$$

(f) Calculate the rate at which energy is dissipated in the circuit.

$$P = IV = 120\times 35 = 4200\ W \text{ or } J/s$$

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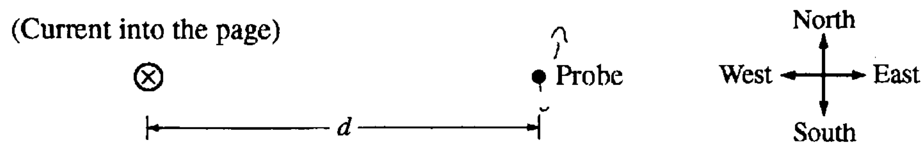
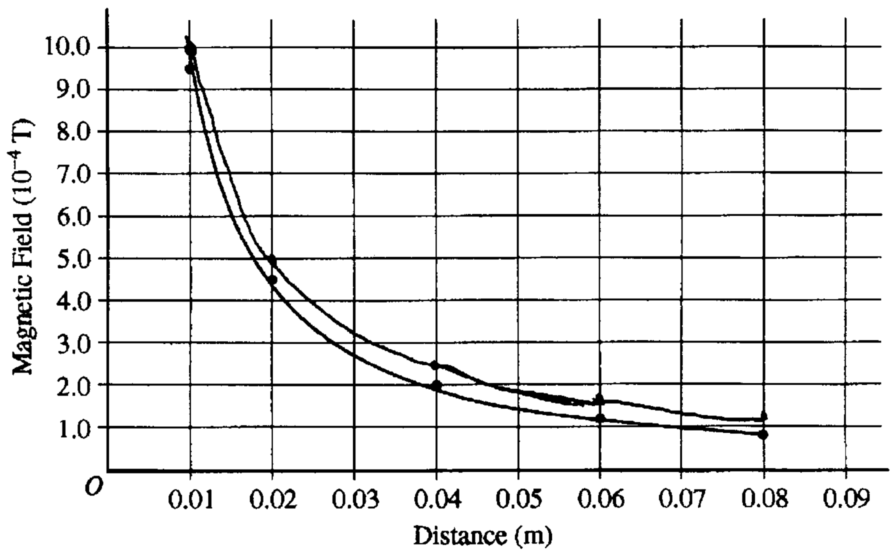


3. (15 points)

A student is measuring the magnetic field generated by a long, straight wire carrying a constant current. A magnetic field probe is held at various distances d from the wire, as shown above, and the magnetic field is measured. The graph below shows the five data points the student measured and a best-fit curve for the data. Unfortunately, the student forgot about Earth's magnetic field, which has a value of 5.0×10^{-5} T at this location and is directed north.



(a) On the graph, plot new points for the field due only to the wire.

(b) Calculate the value of the current in the wire.

$B = \frac{\mu_0}{2\pi} \frac{I}{r}$

$10 \times 10^{-4} = \frac{4\pi \times 10^{-7}}{2\pi} \cdot \frac{I}{0.01}$

$I = 5.06$ A.

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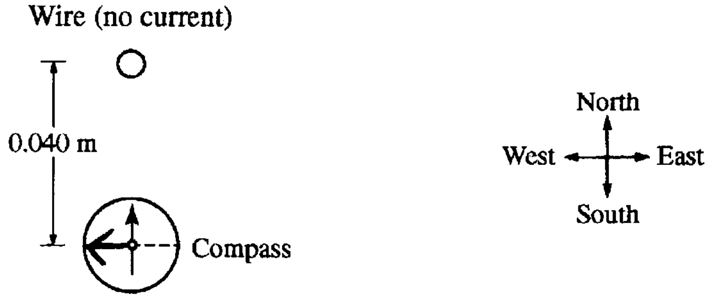
Another student, who does not have a magnetic field probe, uses a compass and the known value of Earth's magnetic field to determine the magnetic field generated by the wire. With the current turned off, the student places the compass 0.040 m from the wire, and the compass points directly toward the wire as shown below. The student then turns on a 35 A current directed into the page.



Note: Figure not drawn to scale.

(c) On the compass, sketch the general direction the needle points after the current is established.

(d) Calculate how many degrees the compass needle rotates from its initial position pointing directly north.

The wire is part of a circuit containing a power source with an emf of 120 V and negligible internal resistance.

(e) Calculate the total resistance of the circuit.

$R = \frac{V}{I} = \frac{120}{35} = 3.428$

Resistance = 3.428 Ω

(f) Calculate the rate at which energy is dissipated in the circuit.

$P = IV$

$= 35 \times 120$

$= 4200$ W.

$P = 4200$W

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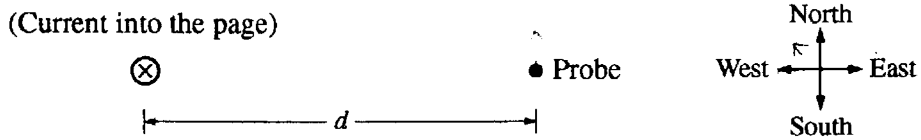
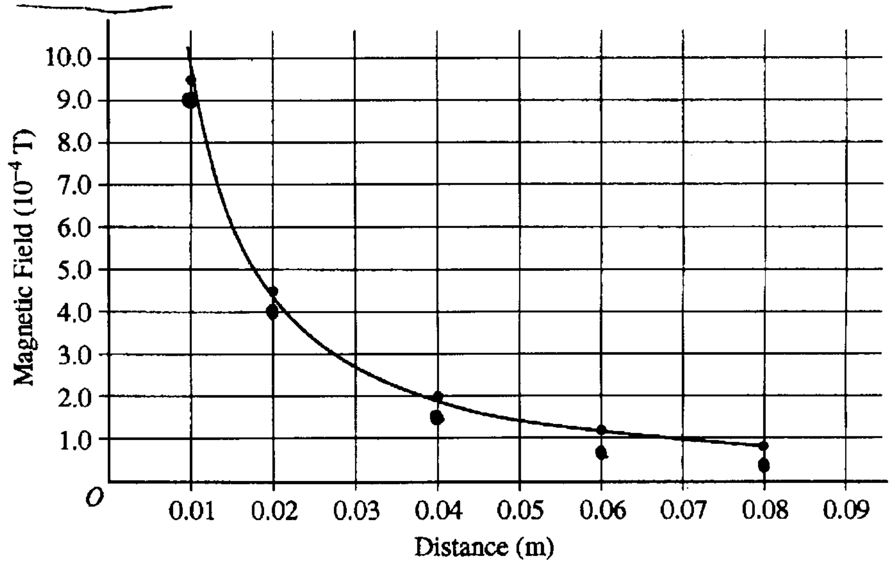


3. (15 points)

A student is measuring the magnetic field generated by a long, straight wire carrying a constant current. A magnetic field probe is held at various distances d from the wire, as shown above, and the magnetic field is measured. The graph below shows the five data points the student measured and a best-fit curve for the data. Unfortunately, the student forgot about Earth's magnetic field, which has a value of 5.0×10^{-5} T at this location and is directed north.



(a) On the graph, plot new points for the field due only to the wire.

(b) Calculate the value of the current in the wire.

Cal I

$B = \frac{\mu_0}{2\pi} \frac{I}{r}$

$I = \frac{2\pi B d}{\mu_0}$

$= 2\pi$

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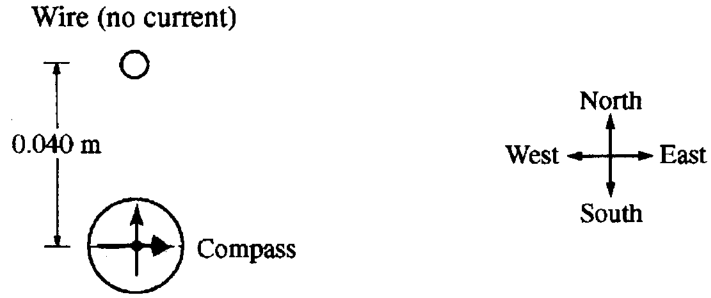
Another student, who does not have a magnetic field probe, uses a compass and the known value of Earth's magnetic field to determine the magnetic field generated by the wire. With the current turned off, the student places the compass 0.040 m from the wire, and the compass points directly toward the wire as shown below. The student then turns on a 35 A current directed into the page.



Note: Figure not drawn to scale.

(c) On the compass, sketch the general direction the needle points after the current is established.

(d) Calculate how many degrees the compass needle rotates from its initial position pointing directly north.

Cal θ

The wire is part of a circuit containing a power source with an emf of 120 V and negligible internal resistance.

(e) Calculate the total resistance of the circuit.

Cal R

$V = IR$

$R = \frac{V}{I} = \frac{120V}{35A} = 3.4\ \Omega$

(f) Calculate the rate at which energy is dissipated in the circuit.

Cal E

$P = VI$

$\frac{E}{t} = VI$

$= 120V \cdot 35A$

$= 4200 \frac{J}{s}$

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Question 3

Sample: B3A
Score: 15

Full credit was given for all parts, as all work shown is correct.

Sample: B3B
Score: 9

The points plotted in part (a) are correct, so the full 2 points were awarded. In part (b) points for proper use of the correct equation, with correct substitutions, were given; however, a calculation error resulted in the loss of the answer point. The needle in part (c) is drawn pointing directly to the west, so a single point was earned. No work is shown in part (d). The calculations in parts (e) and (f) are entirely correct, so the full 2 points were earned for each.

Sample: B3C
Score: 5

The magnitude of the Earth's magnetic field is subtracted from the measured field in part (a), missing the fact that the two fields oppose each other, so no credit was earned. One point was given for using the correct relationship to find an expression for the current in part (b), though no additional work is shown. No points were given for part (c), which is incorrect, and part (d), which shows no substantive work. Parts (e) and (f) both earned full credit.