AP® PHYSICS B (Form B)
2007 SCORING GUIDELINES

General Notes About 2007 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 one 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 and 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 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.

AP® PHYSICS B
2007 SCORING GUIDELINES (Form B)

Question 5

10 points total **Distribution of points**

(a)

(i) 3 points

For recognition that one component of the force is $P_{atm}A$ 1 point

For recognition that another component of the force is Mg 1 point

$F = P_{atm}A + Mg$

For $A = \pi\left(\frac{D}{2}\right)^2 = \frac{\pi D^2}{4}$ 1 point

$F = \frac{P_{atm}\pi D^2}{4} + Mg$

(ii) 1 point

For $P = \frac{F}{A}$, with answer to (a) substituted for F 1 point

$P_{abs} = \frac{\frac{P_{atm}\pi D^2}{4} + Mg}{\frac{\pi D^2}{4}}$

$P_{abs} = P_{atm} + \frac{4Mg}{\pi D^2}$

(b) 3 points

For checking the "Pressure goes up" answer space 1 point

For a correct and complete justification, 2 points were awarded, with partial credit given where appropriate

Example:

For indicating that if heat is added, then the temperature must increase, recognizing that the volume is constant 1 point

For then using the ideal gas law to show that with the volume constant, an increase in temperature implies an increase in pressure 1 point

Alternate example *Alternate points*

For indicating that if heat is added, then the internal energy and thus the kinetic energy of the gas molecules must increase, recognizing that the volume is constant *1 point*

For then indicating that as the kinetic energy of the gas molecules increase, they exert more force on the walls of the cylinder, thus increasing the pressure *1 point*

Question 5 (continued)

Distribution of points

(c) 3 points

For correct equation for work in terms of force and distance — 1 point

$W = Fx$

For correct substitution of x_0 for x — 1 point

$W = Fx_0$

For substitution of force from part (a)(i) — 1 point

$$W = \left(\frac{P_{atm}\pi D^2}{4} + Mg\right)x_0$$

Alternate solution — *Alternate points*

For correct equation for work in terms of pressure and volume change — *1 point*

$W = P_{abs}\,\Delta V$

For correct expression for ΔV — *1 point*

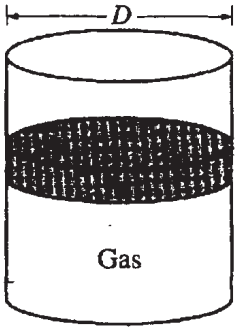
$$\Delta V = x_0 A = x_0 \frac{\pi D^2}{4}$$

$$W = P_{abs}x_0\left(\frac{\pi D^2}{4}\right)$$

For substitution of absolute pressure from part (a)(ii) — *1 point*

$$W = \left(P_{atm} + \frac{4Mg}{\pi D^2}\right)x_0\left(\frac{\pi D^2}{4}\right)$$

$$W = \left(\frac{P_{atm}\pi D^2}{4} + Mg\right)x_0$$



5. (10 points)

The cylinder above contains an ideal gas and has a movable, frictionless piston of diameter D and mass M. The cylinder is in a laboratory with atmospheric pressure P_{atm}. Express all algebraic answers in terms of the given quantities and fundamental constants.

(a) Initially, the piston is free to move but remains in equilibrium. Determine each of the following.

i. The force that the confined gas exerts on the piston

the force that the confined gas exerts on the piston : F_{gas}

$$Mg + P_{atm} \times \left(\frac{1}{2}D\right)^2 \pi = F_{gas}$$

$$F_{gas} = Mg + \frac{P_{atm} D^2 \pi}{4}$$

ii. The absolute pressure of the confined gas

$$P_{gas} = \frac{F_{gas}}{A}$$

$$= \frac{Mg + P_{atm} \times \left(\frac{1}{2}D\right)^2 \pi}{\left(\frac{1}{2}D\right)^2 \pi} = \frac{4Mg}{D^2 \pi} + P_{atm}$$

(b) If a net amount of heat is transferred to the confined gas when the piston is fixed, what happens to the pressure of the gas?

✓ Pressure goes up. ____ Pressure goes down. ____ Pressure stays the same.

Explain your reasoning.

from the ideal gas equation

$PV = nRT$

when heat is transferred to the gas, meaning that the temperature rises, if volume is fixed pressure goes up.

GO ON TO THE NEXT PAGE.

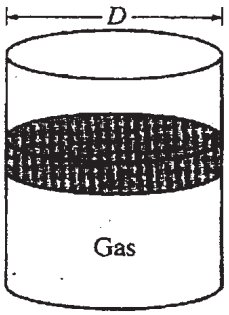
(c) In a certain process the absolute pressure of the confined gas remains constant as the piston moves up a distance x_0. Calculate the work done by the confined gas during the process.

$$W = P\Delta V$$

$$= P_{gas} \times \left(\frac{D^2}{4}\pi \times x_0\right)$$

$$= \left(\frac{4Mg}{D^2\pi} + P_{atm}\right) \times \left(\frac{D^2\pi x_0}{4}\right)$$

$$= Mgx_0 + \frac{D^2\pi x_0 P_{atm}}{4}$$



5. (10 points)

The cylinder above contains an ideal gas and has a movable, frictionless piston of diameter D and mass M. The cylinder is in a laboratory with atmospheric pressure P_{atm}. Express all algebraic answers in terms of the given quantities and fundamental constants.

(a) Initially, the piston is free to move but remains in equilibrium. Determine each of the following.

i. The force that the confined gas exerts on the piston

$P = \frac{F}{A}$ $\therefore$ $F = PA = P\left(\frac{\pi D^2}{4}\right) = \boxed{\frac{P\pi D^2}{4}}$

ii. The absolute pressure of the confined gas

$P = \frac{F}{A} = \frac{F}{\frac{\pi D^2}{4}}$ $\boxed{\frac{4F}{\pi D^2}}$

(b) If a net amount of heat is transferred to the confined gas when the piston is fixed, what happens to the pressure of the gas?

✓ Pressure goes up. ___ Pressure goes down. ___ Pressure stays the same.

Explain your reasoning.

as temperature increases, the molecules of the gas move faster Thus colliding on the piston more frequently & vigorously to increase in pressure

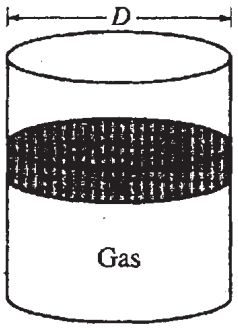
GO ON TO THE NEXT PAGE.

(c) In a certain process the absolute pressure of the confined gas remains constant as the piston moves up a distance x_0. Calculate the work done by the confined gas during the process.

$W = Fd = (PA)(x_0)$

$= (P \cdot \frac{\pi D^2}{4})(x_0)$

$= (\frac{P \pi D^2}{4})(x_0)$ J



5. (10 points)

The cylinder above contains an ideal gas and has a movable, frictionless piston of diameter D and mass M. The cylinder is in a laboratory with atmospheric pressure P_{atm}. Express all algebraic answers in terms of the given quantities and fundamental constants.

(a) Initially, the piston is free to move but remains in equilibrium. Determine each of the following.

i. The force that the confined gas exerts on the piston

$P = \frac{F}{A}$ $F = AP_{atm}$

ii. The absolute pressure of the confined gas

$P = \frac{nRT}{V}$

(b) If a net amount of heat is transferred to the confined gas when the piston is fixed, what happens to the pressure of the gas?

✓ Pressure goes up. ____ Pressure goes down. ____ Pressure stays the same.

Explain your reasoning.

Because $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ and Volume stays constant, if heat is added, temperature increases, therefore P_2 (pressure on the gas) must increase proportionally.

(c) In a certain process the absolute pressure of the confined gas remains constant as the piston moves up a distance x_0. Calculate the work done by the confined gas during the process.

$W = -P\Delta V$

AP® PHYSICS B
2007 SCORING COMMENTARY (Form B)

Question 5

Sample: B5A
Score: 10

This student uses the alternate solution for part (c).

Sample: B5B
Score: 7

In part (a)(i) the term for the weight of the piston is missing, so only 2 points were earned. Part (a)(ii) received no credit. Only 2 points were earned in part (b) because there is no mention of constant volume in the explanation. Part (c) received full credit for correctly using the incorrect answer from part (a)(i).

Sample: B5C
Score: 4

Part (a)(i) received 1 point for the atmospheric pressure term. Part (a)(ii) received no credit, and part (b) received full credit. Part (c) also received no credit because this response shows the expression for the work done on the gas, not by the gas.