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 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
2008 SCORING GUIDELINES (Form B)

Question 2

15 points total **Distribution of points**

(a) 2 points

For correct use of a kinematic relationship to find acceleration, and correct substitution of values 1 point

$$x = x_0 + v_0 t - \frac{1}{2}at^2$$

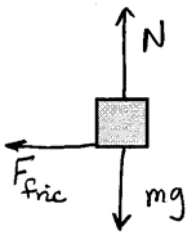
$$a = -\frac{2[(x - x_0) - v_0 t]}{t^2}$$

$$a = \frac{2[55\text{ m} - (25\text{ m/s})(3.0\text{ s})]}{(3.0\text{ s})^2}$$

For the correct final answer, regardless of sign or units 1 point

$a = -4.4\ \text{m/s}^2$

(b) 3 points



For each correct force for which the vector was correctly drawn and labeled, 1 point was awarded. 3 points

For each extraneous or incorrect force vector, 1 point was deducted with the minimum possible score being zero.

(c)

(i) 3 points

For equating the frictional force to *ma* 1 point

$\Sigma F = F_{fric} = ma$

For a correct expression for the frictional force 1 point

$F_{fric} = \mu N = \mu mg$

Substituting the expression for F_{fric} into Newton's second law

$\mu mg = ma$

$$\mu = \frac{a}{g} = \frac{4.4\ \text{m/s}^2}{9.8\ \text{m/s}^2}$$

For the correct final answer, without units 1 point

$\mu = 0.45$ ($\mu = 0.44$ for $g = 10\ \text{m/s}^2$)

Question 2 (continued)

Distribution of points

(ii) 1 point

For indicating that the friction is static — 1 point

(d) 3 points

For correct use of a kinematic relationship to find acceleration — 1 point

$v = v_0 + at$

$a_x = \frac{v_x - v_{0x}}{t} = \frac{25 \text{ m/s} - 0 \text{ m/s}}{10 \text{ s}} = 2.5 \text{ m/s}^2$

For correct substitutions into Newton's second law — 1 point

$\Sigma F = ma = kx$

$kx = ma_x$

$x = \frac{ma}{k} = \frac{(900 \text{ kg})(2.5 \text{ m/s}^2)}{9200 \text{ N/m}}$

For the correct answer with units — 1 point

$x = 0.24$ m

(e) 3 points

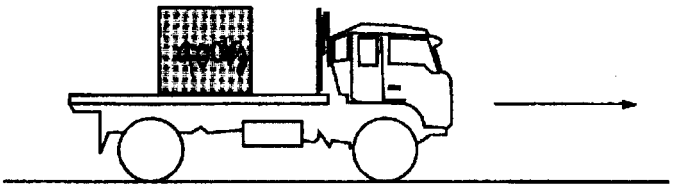
For indicating that the extension of the spring is less than in part (d) — 1 point

For a correct justification — 2 points

For example: When the truck is moving at a constant speed, the crate is also moving at the same constant speed with zero acceleration. This means the net force on the crate must be zero; since the bed of the truck is frictionless, the force of the spring on the crate must also zero, and so the spring is not extended at all.

Notes: A single point could be awarded for partial justification, e.g., for either of the statements above given in the absence of the other.

The justification points could only be earned if the point was awarded for the proper extension of the spring.



2. (15 points)

A 4700 kg truck carrying a 900 kg crate is traveling at 25 m/s to the right along a straight, level highway, as shown above. The truck driver then applies the brakes, and as it slows down, the truck travels 55 m in the next 3.0 s. The crate does not slide on the back of the truck.

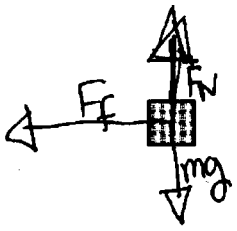
(a) Calculate the magnitude of the acceleration of the truck, assuming it is constant.

$d = v_i t + \frac{at^2}{2}$

$55 = 25(3) + \frac{a(3)^2}{2}$

$a = -4.44 \text{ m/s}^2$

(b) On the diagram below, draw and label all the forces acting on the crate during braking.



(c)

i. Calculate the minimum coefficient of friction between the crate and truck that prevents the crate from sliding.

$\Sigma F = ma = 0$

$900 \cdot 4.44 = 3996 \text{ N}$

$3996 = F_f$ $\qquad$ $3996 = 9000 \mu_s$

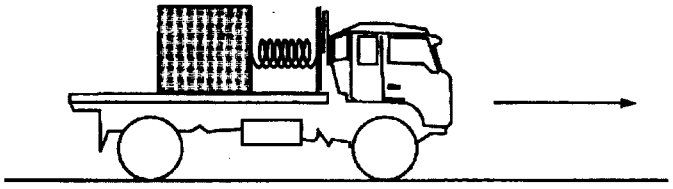
$3996 = F_N \cdot \mu_s$ $\qquad$ $\mu_s = 0.444$

ii. Indicate whether this friction is static or kinetic.

V Static ____Kinetic

GO ON TO THE NEXT PAGE.

Now assume the bed of the truck is frictionless, but there is a spring of spring constant 9200 N/m attaching the crate to the truck, as shown below. The truck is initially at rest.



(d) If the truck and crate have the same acceleration, calculate the extension of the spring as the truck accelerates from rest to 25 m/s in 10 s.

$a = \frac{V_f - V_i}{\Delta t} = \frac{25-0}{10} = 2.5 m/s^2$

$\Sigma F = 900 \cdot 2.5 = 2250 N$

$9200x = 2250$

$x = 4.09 m$

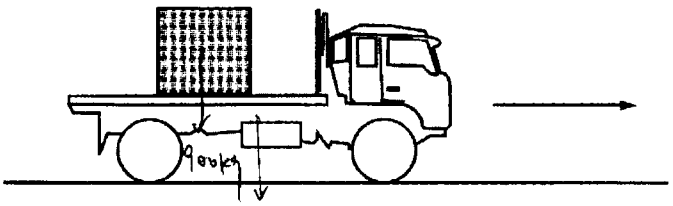
(e) At some later time, the truck is moving at a constant speed of 25 m/s and the crate is in equilibrium. Indicate whether the extension of the spring is greater than, less than, or the same as in part (d) when the truck was accelerating.

___ Greater V Less ___ The same

Explain your reasoning.

since it is moving at a constant speed, acceleration is zero. If acceleration is zero, net force is zero on the crate. If net force is zero and the crate is in equlibrium, the spring wouldn't extend.

GO ON TO THE NEXT PAGE.



2. (15 points)

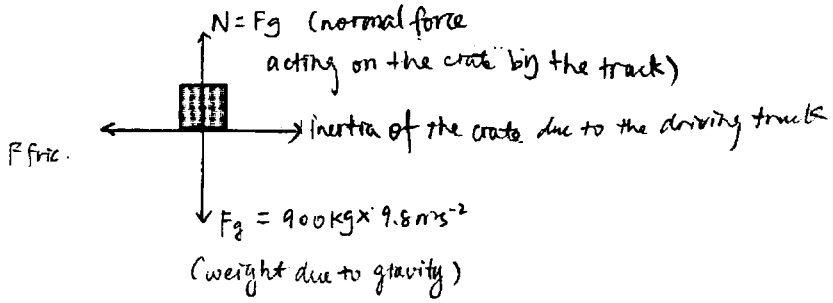
A 4700 kg truck carrying a 900 kg crate is traveling at 25 m/s to the right along a straight, level highway, as shown above. The truck driver then applies the brakes, and as it slows down, the truck travels 55 m in the next 3.0 s. The crate does not slide on the back of the truck.

(a) Calculate the magnitude of the acceleration of the truck, assuming it is constant.

$x = x_0 + v_0 t + \frac{1}{2} a t^2$

$a = \frac{x - x_0 - v_0 t}{\frac{1}{2} t^2} = \frac{55\,m - 0 - 25\,m s^{-1} \times 3.0\,s}{\frac{1}{2} \times (3.0\,s)^2} = -4.44\,m s^{-2}$ (3. s.f)

(b) On the diagram below, draw and label all the forces acting on the crate during braking.



(c)

i. Calculate the minimum coefficient of friction between the crate and truck that prevents the crate from sliding.

$F \leq \mu N$

$\therefore a = -4.44\,m s^{-2}$

$\therefore |F| = |ma| = |(900kg + 4700kg)(-4.44\,m s^{-2})| = 24888.9\,N$

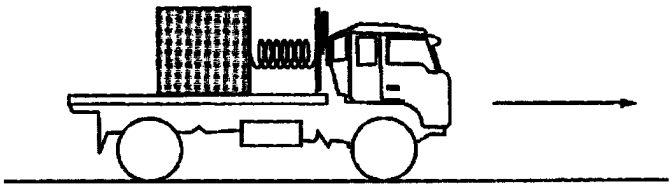
$\therefore \mu = \frac{F}{N} = \frac{F}{Fg} = \frac{F}{mg} = \frac{+24888.9\,N}{900kg \times 9.8\,m s^{-2}} = 2.82$

ii. Indicate whether this friction is static or kinetic.

✓ Static ____ Kinetic

GO ON TO THE NEXT PAGE.

Now assume the bed of the truck is frictionless, but there is a spring of spring constant 9200 N/m attaching the crate to the truck, as shown below. The truck is initially at rest.



(d) If the truck and crate have the same acceleration, calculate the extension of the spring as the truck accelerates from rest to 25 m/s in 10 s.

$\because F_S = -kx$

$\because V_0 = 0$

$V = 25 ms^{-1}$

$t = 10s$

$\therefore x = \frac{F_S}{-k} = \frac{F_{crate}}{-k} = \frac{2250N}{-9200 Nm^{-1}}$

$= -0.2446 m \approx -0.245 m$ (3.s.f)

$\therefore V = V_0 + at$

$a = \frac{V - V_0}{t} = \frac{25 ms^{-1} - 0}{10s} = 2.5 ms^{-2}$

i.e. The spring extends by 0.245 m to the left.

$\therefore F_{crate} = ma = 900kg \times 2.5 ms^{-2}$

$= 2250N$

(e) At some later time, the truck is moving at a constant speed of 25 m/s and the crate is in equilibrium. Indicate whether the extension of the spring is greater than, less than, or the same as in part (d) when the truck was accelerating.

___ Greater ___ Less ✓ The same

Explain your reasoning.

$\because$ Truck is moving with a constant speed

$\therefore a = 0$

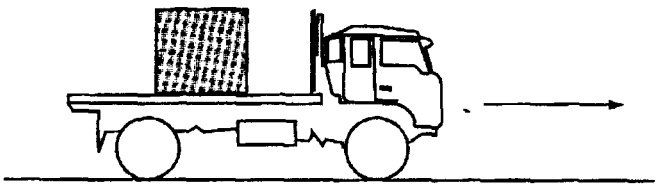
$\therefore F_C' = ma = 0.$

$\therefore x = \frac{F_S}{-k} = \frac{F_C}{-k} = 0$

i.e. There is no further extension in the spring since the acceleration is zero now.

The extension in spring will be the same as in part d).

GO ON TO THE NEXT PAGE.



2. (15 points)

A 4700 kg truck carrying a 900 kg crate is traveling at 25 m/s to the right along a straight, level highway, as shown above. The truck driver then applies the brakes, and as it slows down, the truck travels 55 m in the next 3.0 s. The crate does not slide on the back of the truck.

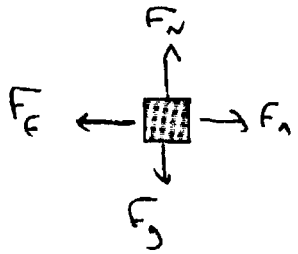
(a) Calculate the magnitude of the acceleration of the truck, assuming it is constant.

$\frac{1}{2}mv^2 =$

$\frac{1}{2} \cdot 4700 \cdot 25$

$=$

(b) On the diagram below, draw and label all the forces acting on the crate during braking.



(c)

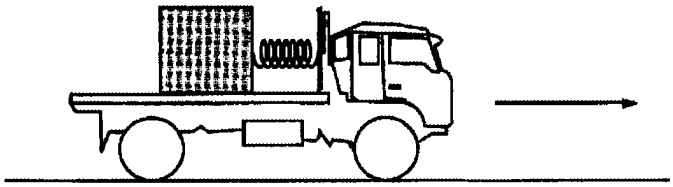
i. Calculate the minimum coefficient of friction between the crate and truck that prevents the crate from sliding.

ii. Indicate whether this friction is static or kinetic.

✓ Static ___Kinetic

GO ON TO THE NEXT PAGE.

Now assume the bed of the truck is frictionless, but there is a spring of spring constant 9200 N/m attaching the crate to the truck, as shown below. The truck is initially at rest.



(d) If the truck and crate have the same acceleration, calculate the extension of the spring as the truck accelerates from rest to 25 m/s in 10 s.

$v = v_0 + at$

$25 = 0 + 10a$

$\frac{25}{10} = a$

$a = 2.5$

(e) At some later time, the truck is moving at a constant speed of 25 m/s and the crate is in equilibrium. Indicate whether the extension of the spring is greater than, less than, or the same as in part (d) when the truck was accelerating.

___ Greater ___ Less ✓ The same

Explain your reasoning.

Because it is in equilibrium

GO ON TO THE NEXT PAGE.

AP® PHYSICS B
2008 SCORING COMMENTARY (Form B)

Question 2

Sample: B2A
Score: 14

Full credit was awarded for parts (a), (b), (c), and (e). Part (d) was awarded 2 points for the correct use of a kinematic relationship and substitution into Newton's second law; however, the answer point was lost due to an algebraic error.

Sample: B2B
Score: 9

In part (a) both points were awarded for correctly determining the acceleration of the truck. All three forces acting on the crate during braking are properly shown in the free-body diagram, but only 2 points were awarded, as there is also an extraneous "inertia" force drawn on the diagram. In part (c)(i), a correct expression for the frictional force is used, but Newton's second law is not set up properly, leading to an incorrect answer. The friction is correctly identified as being static, so a total of 2 points were awarded for part (c). Full credit was awarded for part (d). No credit was awarded for part (e), as the selected choice is incorrect.

Sample: B2C
Score: 4

No substantive work is performed for part (a). The free-body diagram in part (b) includes all three correct forces but also includes a fourth extraneous force, so only 2 points were awarded for that part. No work is shown for part (c)(i), but 1 point was awarded for a correct choice in part (c)(ii). One point was awarded for correctly using a kinematic relationship to find the acceleration in part (d), but no additional work is done. No credit was awarded for part (e), as an incorrect choice is selected.