AP® PHYSICS
2011 SCORING GUIDELINES (Form B)

General Notes About 2011 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 earned. 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 earn 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 earned. 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*.

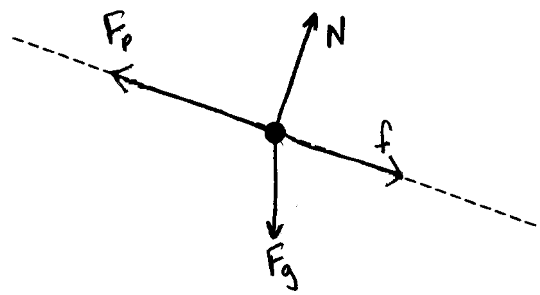
4. The scoring guidelines typically show numerical results using the value $g = 9.8\ \text{m/s}^2$, but use of $10\ \text{m/s}^2$ is also acceptable. Solutions usually show numerical answers using both values when they are significantly different.

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 earn 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 1

15 points total | **Distribution of points**

(a) 4 points



For each correct force on the dot for which the vector drawn has the correct direction and a correct label such as those in the figure above, 1 point was earned. — 4 points

No points were earned for an appropriately labeled force if the direction was incorrect.

1 earned point was deducted for each additional force or component.

(b) 2 points

Applying Newton's second law to the forces perpendicular to the plane

$\Sigma F_{\perp} = ma_{\perp}$, where $a_{\perp} = 0$

$N - F_g \cos\theta = 0$

$N - mg\cos\theta = 0$

For a correction expression for the normal force — 1 point

$N = mg\cos\theta$ (or $N = mg\sin\theta$, if $70°$ was clearly used for θ)

For correctly substituting the values of m, g and θ into the correct expression — 1 point

$N = (50 \text{ kg})(9.8 \text{ m/s}^2)\cos 20°$

$N = 460 \text{ N}$ (or 470 N using $g = 10 \text{ m/s}^2$)

(c) 2 points

For a correct expression for the component of the force of gravity parallel to the plane — 1 point

$F_{g_{||}} = F_g \sin\theta = mg\sin\theta$ (or $mg\cos\theta$, if $70°$ was clearly used for θ)

$F_{g_{||}} = (50 \text{ kg})(9.8 \text{ m/s}^2)\sin(20°)$

For a correct answer — 1 point

$F_{g_{||}} = 168 \text{ N}$ (or 171 N using $g = 10 \text{ m/s}^2$)

Question 1 (continued)

Distribution of points

(c) (continued)

Alternate solution — *Alternate points*

For indicating $F_{g\|} = \sqrt{F_g{}^2 - F_{g\perp}{}^2}$ — *1 point*

$F_g = mg = (50 \text{ kg})(10 \text{ m/s}^2) = 500 \text{ N}$

$F_{g\perp} = mg\cos\theta = N = 460 \text{ N}$

For a correct answer — *1 point*

$F_{g_{\|}} = 168 \text{ N}$ (or 171 N using $g = 10 \text{ m/s}^2$)

(d) 2 points

For a correct expression for the frictional force — 1 point

$f = \mu_K N$

For correct substitution of μ_K and the value of N from part (b) — 1 point

$f = (0.30)(460 \text{ N})$

$f = 138 \text{ N}$ (or 141 N using the $g = 10 \text{ m/s}^2$ result of $N = 470 \text{ N}$ from (b))

(e) 2 points

Applying Newton's second law to the forces parallel to the plane

$F_{\text{net}\|} = \Sigma F_{\|} = ma_{\|}$, where $a_{\|} = 0$ because the box is moving at constant speed

For indicating $F_{\text{net}\|} = 0$ — 1 point

$F_{\text{net}\|} = F_p - F_{g_{\|}} - f = 0$

For correct substitutions of the answers from parts (c) and (d) into a correct expression — 1 point

$F_P = F_{g\|} + f$

$F_p = 168 \text{ N} + 138 \text{ N}$

$F_p = 306 \text{ N}$ (or 312 N using the $g = 10 \text{ m/s}^2$ results of $F_{g_{\|}} = 171 \text{ N}$ and $f = 141 \text{ N}$)

Question 1 (continued)

Distribution of points

(f) 2 points

For a correct expression relating work to force and distance — 1 point

$W = Fd\cos\phi$, where ϕ is the angle between **F** and **d**

(W = force times distance must be implied, not $W = mgh$. It was acceptable if ϕ was not explicitly included because $\cos\phi = \cos 0° = 1$.)

For correctly substituting the force from part (e) and $d = \dfrac{3.0\text{ m}}{\sin 20°}$ or 8.8 m — 1 point

$W = 306\text{ N}\left(\dfrac{3.0\text{ m}}{\sin 20°}\right)$

$W = 2684\text{ J}$ (or 2737 J using the $g = 10\text{ m/s}^2$ result of $F_p = 312\text{ N}$)

Units 1 point

For correct units on at least three answers and no incorrect units — 1 point

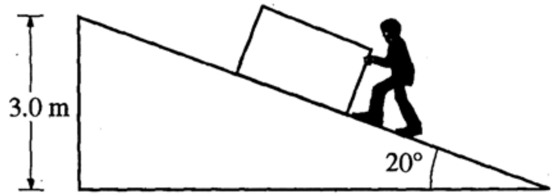
PHYSICS B

SECTION II

Time—90 minutes

6 Questions

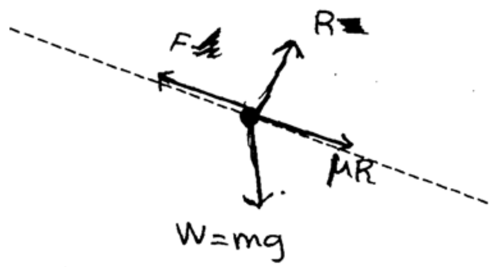
Directions: Answer all six questions, which are weighted according to the points indicated. The suggested times are about 17 minutes for answering each of Questions 1-3 and 5, and about 11 minutes for answering each of Questions 4 and 6. The parts within a question may not have equal weight. Show all your work in this booklet in the spaces provided after each part, NOT in the lavender insert.



1. (15 points)

A box is being pushed at constant speed up an inclined plane to a vertical height of 3.0 m above the ground, as shown in the figure above. The person exerts a force parallel to the plane. The mass m of the box is 50 kg, and the coefficient of kinetic friction μ_k between the box and the plane is 0.30.

(a) On the dot below that represents the box, draw and label the forces (not components) acting on the box.



(b) Calculate the normal force of the plane on the box. If you need to draw anything other than what you have shown in part (a) to assist in your solution, use the space below. Do NOT add anything to the figure in part (a).

$R = mg\cos 20° = 469.8\text{N}$

GO ON TO THE NEXT PAGE.

(c) Calculate the component of the force of gravity acting on the box that is parallel to the plane.

$W\sin 20 = 500 \sin 20° = 171\text{ N}$

(d) Calculate the friction force between the plane and the box.

$F_r = \mu R = 140.9\text{ N}$

(e) Calculate the force applied by the person on the box.

$Mg \sin 20° + \mu mg \cos 20° = 500(0.34 + 0.281) = 310°$

(f) Calculate the work done by the person pushing the box, assuming the box is raised to the vertical height of 3.0 m.

$W = mgh = 500 \times 3 = 1500\text{ J}$

GO ON TO THE NEXT PAGE.

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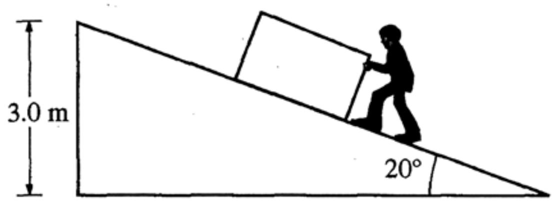

h= 3.0
m= 50kg
μk= .30

1. (15 points)

A box is being pushed at constant speed up an inclined plane to a vertical height of 3.0 m above the ground, as shown in the figure above. The person exerts a force parallel to the plane. The mass m of the box is 50 kg, and the coefficient of kinetic friction μ_k between the box and the plane is 0.30.

(a) On the dot below that represents the box, draw and label the forces (not components) acting on the box.

Fm = man pushing
Ff = friction
FN = normal Force

(b) Calculate the normal force of the plane on the box. If you need to draw anything other than what you have shown in part (a) to assist in your solution, use the space below. Do NOT add anything to the figure in part (a).

Fn = Fw

Fn = (50 kg)(9.8 m/s²)

= 490N

GO ON TO THE NEXT PAGE.

(c) Calculate the component of the force of gravity acting on the box that is parallel to the plane.

$A_g = 9.8\ m/s^2$

$F_w = (50Kg)(9.8m/s^2)$

$F_w = 490N$

(d) Calculate the friction force between the plane and the box.

$F_{KF} = \mu_K F$

$F_{KF} = (.3)(490N)$

$F_{KF} = 147N$

(e) Calculate the force applied by the person on the box.

$F_p = \sin(20) F_N + F_F$

$F_p = \sin(20)(490N) + 147N$

$F_p = 314.59N$

(f) Calculate the work done by the person pushing the box, assuming the box is raised to the vertical height of 3.0 m.

$W = F \Delta r \cos(\theta)$

$W = (314.59N)(3.0m)\cos(20)$

$W = 886.854J$

GO ON TO THE NEXT PAGE.

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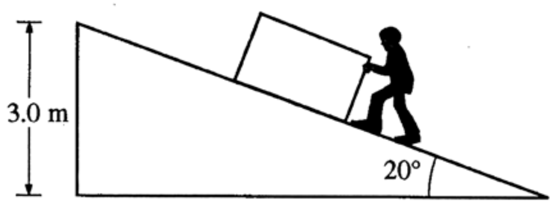

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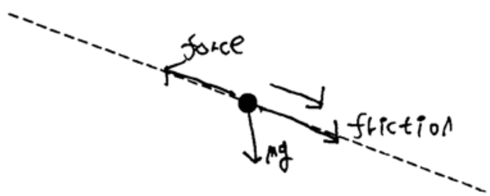

(b) Calculate the normal force of the plane on the box. If you need to draw anything other than what you have shown in part (a) to assist in your solution, use the space below. Do NOT add anything to the figure in part (a).

Mg sin20 447.343

50 × 9.8 × sin20

GO ON TO THE NEXT PAGE.

(c) Calculate the component of the force of gravity acting on the box that is parallel to the plane.

$Mg = 490$

(d) Calculate the friction force between the plane and the box.

$Mg \cos 20 \times \mu_k$

59.9881

(e) Calculate the force applied by the person on the box.

force = friction + normal force

507.331

(f) Calculate the work done by the person pushing the box, assuming the box is raised to the vertical height of 3.0 m.

determine length is L

1617.12

$\frac{3}{L} = \sin 20$

$L = \frac{3}{\sin 20}$

$W = \frac{3}{\sin 20} \times 507.331$

GO ON TO THE NEXT PAGE.

Question 1

Sample: B1A
Score: 13

The response shows the necessary work leading to the answers. The response earned full credit for parts (a) through (e). The student used an incorrect expression for work in part (f) and did not earn credit. The units are missing in part (e) but are correct everywhere else, so the units point was earned.

Sample: B1B
Score: 8

The response lost 1 point in part (a) because the normal force is in the wrong direction. No points were earned in parts (b) or (c). Part (d) received full credit because the answer is consistent with the normal force determined in part (b). Part (e) does not have a correct equilibrium expression and has an error in the equation written; thus no points were earned. Part (f) used the correct work equation but did not earn a point for the wrong distance. The units point was earned.

Sample: B1C
Score: 5

The response earned 3 points in part (a) for the three correct forces but then lost 1 point for the fourth unlabeled arrow. Parts (b) and (c) earned no credit. In part (d) the expression is correct but the answer is wrong so only 1 point was earned. Part (e) earned no credit. The response in part (f) is consistent with the force from part (e) and earned full credit. No units are included, so that point was not earned.