

**AP[®] PHYSICS C: MECHANICS
2012 SCORING GUIDELINES**

Question 3

15 points total

**Distribution
of points**

(a)

i. 3 points

For starting with Newton's second law for translation, with friction as the net force

1 point

$$\Sigma F = -f = Ma$$

For a correct expression for the frictional force

1 point

$$f = \mu Mg$$

For indicating that linear acceleration is the time derivative of velocity

1 point

$$a = \frac{dv}{dt}$$

$$\frac{dv}{dt} = -\mu g$$

ii. 3 points

For starting with Newton's second law for rotation, with a correct substitution for the rotational inertia

1 point

$$\tau = MR^2\alpha$$

For a correct expression for the torque, using the frictional force

1 point

$$\tau = \mu MgR$$

For indicating that the angular acceleration is the time derivative of the angular velocity

1 point

$$\alpha = \frac{d\omega}{dt}$$

$$\frac{d\omega}{dt} = \frac{\mu g}{R}$$

(b)

i. 2 points

For setting up the integral of the function determined in part (a)-i

1 point

$$\int_{v_0}^v dv = -\int_0^t \mu g dt$$

For the correct answer

1 point

$$v = v_0 - \mu gt$$

Alternate solution

Alternate points

For a clear substitution of the acceleration from part (a)-i into the kinematics equation

1 point

$$a = -\mu g$$

$$v = v_0 + at$$

For the correct answer

1 point

$$v = v_0 - \mu gt$$

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Question 3 (continued)

	Distribution of points
(b) continued	
ii. 2 points	
For setting up the integral of the function determined in part (a)-ii	1 point
$\int_0^{\omega} d\omega = \int_0^t (\mu g/R) dt$	
For the correct answer	1 point
$\omega = \mu g t / R$	
<i>Alternate solution</i>	<i>Alternate points</i>
<i>For a clear substitution of the angular acceleration from part (a)-ii into the correct rotational kinematics equation</i>	<i>1 point</i>
$\alpha = \frac{\mu g}{R}$	
$\omega = \omega_0 + \alpha t$	
<i>For the correct answer</i>	<i>1 point</i>
$\omega = \mu g t / R$	
(c) 2 points	
For indicating that the linear speed is equal to $R\omega$ when the slipping stops	1 point
$v = R\omega$	
$v_0 - \mu g t = R \left(\frac{\mu g t}{R} \right)$	
For the correct answer	1 point
$t = \frac{v_0}{2\mu g}$	
(d) 1 point	
For substituting the time found in part (c) into a correct kinematics equation	1 point
$v = v_0 - \mu g \left(\frac{v_0}{2\mu g} \right)$	
$v = v_0 / 2$	

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Question 3 (continued)

	Distribution of points
(e) 2 points	
For setting up the integral of the velocity function determined in part (b)-i	1 point
$L = \int_0^t (v_0 - vgt) dt$	
For the correct answer, with correct supporting work	1 point
$L = \left[v_0 t - \frac{1}{2} \mu g t^2 \right]_0^{\frac{v_0}{2\mu g}}$	
$L = \frac{3v_0^2}{8\mu g}$	
<i>Alternate solution #1</i>	<i>Alternate points</i>
<i>For substituting the velocity from part (d) and the acceleration from part (a)-i into a correct equation that solves for L</i>	<i>1 point</i>
$v^2 = v_0^2 + 2a\Delta x$	
$\left(\frac{v_0}{2} \right)^2 = v_0^2 + 2(-\mu g)L$	
<i>For the correct answer, with correct supporting work</i>	<i>1 point</i>
$L = \frac{3v_0^2}{8\mu g}$	
<i>Alternate solution #2</i>	<i>Alternate points</i>
<i>For substituting the velocity from part (d) and the acceleration from part (a)-i into a correct equation that solves for L</i>	<i>1 point</i>
<i><u>Note:</u> The time determined in part (c) must also be substituted.</i>	
$\Delta x = v_0 t + \frac{1}{2} at^2$	
$L = v_0 \left(\frac{v_0}{2\mu g} \right) + \frac{1}{2} (-\mu g) \left(\frac{v_0}{2\mu g} \right)^2$	
<i>For the correct answer, with correct supporting work</i>	<i>1 point</i>
$L = \frac{3v_0^2}{8\mu g}$	