AP® Physics C
1980 Scoring Guidelines

Solution	*Distribution of Points*
(a) 3 points The "no slip" condition is	
$a_1 = a_2$	1 point
From Newton's second law,	
$a_1 = \dfrac{f}{m_1}$	1 point
Thus,	
$a_2 = \dfrac{f}{m_1}$	1 point
(b) 5 points The general equation of motion is given by $m\ddot{x} = -kx$ For the "no slip" maximum amplitude	
$m = (m_1 + M_2)$	1 point
$x = A$	1 point
$\ddot{x} = \dfrac{f}{m_1}$	1 point
Solving for the amplitude	
$A = \dfrac{(m_1 + M_2)}{k}\dfrac{f}{m_1}$	2 points
(c) 3 points Any discussion or graph that describes the frictional force as proportional to the sinusoidal acceleration received full credit.	3 points
(d) 4 points i.	
$f = m_1 a_1$	1 point
$a_1 = \dfrac{f}{m_1}$	1 point
ii. $F_{spring} - f = M_2 a_2$	1 point
$a_2 = \dfrac{F_s - f}{M_2}$	1 point
where $F_s = kA'$ or $k\,(A + A')$ depending on how the student interpreted the statement of the problem.	
Total	15 points

1980 C: Mech.-2

Solution	*Distribution of Points*
(a) 4 points	
From conservation of linear momentum	
$mv_0 = mv_1 + 3mv_1$	3 points
$v_1 = \frac{v_0}{4}$	1 point
(b) 5 points	
From conservation of mechanical energy	
$\frac{1}{2}mv_0^2 = \frac{1}{2}(m + 3m)v_1^2 + mgh$	4 points
Substituting for v_1 and solving for the height h	
$h = \frac{3}{8}\frac{v_0^2}{g}$	1 point
(c) 6 points	
From conservation of linear momentum	
$mv_0 = mv' + 3mv_f$	
From conservation of mechanical energy	3 points
$\frac{1}{2}mv_0^2 = \frac{1}{2}mv'^2 + \frac{1}{2}(3m)v_f^2$	
Solving for the final velocities	
$v_f = \frac{v_0}{2}$	1 point
$v' = -\frac{v_0}{2}$	1 point
The block moves to the left.	1 point
Total	15 points

1980 C: Mech.-3

(a) 4 points	
Under the action of the constant force of friction the velocity is given by	
$v = v_0 - at$	1 point
From Newton's second law	
$F = Ma$	1 point
From the definition of the frictional force	
$F = f = \mu N = \mu Mg$	1 point
Thus,	
$v = v_0 - \mu gt$	1 point

Solution — Distribution of Points

(b) 4 points
Under the action of the constant torque about the center of mass due to the frictional force, the angular velocity is given by

$$\omega = \omega_0 + \alpha t$$ 1 point

From Newton's second law, the torque τ is given by

$$\tau = I_c \alpha$$ 1 point

The torque is given by

$$\tau = R\,(\mu M g)$$ 1 point

Thus, since $\omega_0 = 0$,

$$\omega = \left(\frac{5}{2}\right)\left(\frac{\mu g}{R}\right) t$$ 1 point

(c) 4 points
The slipping stops when the tangential velocity v_t is equal to the velocity of the center of mass v.

$$v_t = v$$ 1 point

and

$$v_t = \omega R$$ 1 point

Thus,

$$v_0 - \mu g T = \omega R$$ 1 point

where T is the time required for the slipping to stop. Solving for T,

$$T = \left(\frac{2}{7}\right)\left(\frac{v_0}{\mu g}\right)$$ 1 point

(d) 3 points
Since the line of action of the frictional force passes through P, the net torque about point P (due to all forces) is zero. 1 point
Thus, the time rate of change of the angular momentum is zero. 1 point
Thus, the angular momentum is a constant. 1 point

Total 15 points

1980 C: E&M-1

(a) 3 points
The differential potential at point O due to an incremental charge dq is given by

$$dV_0 = \frac{dq}{4\pi\epsilon_0 R}$$ 1 point

where

$$dq = \lambda R\, d\theta$$ 1 point

Thus,

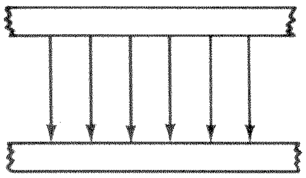
$$V_0 = \frac{\lambda}{4\pi\epsilon_0}\int_0^{\pi} d\theta = \frac{\lambda}{4\epsilon_0} = k\lambda\pi$$ 1 point

(Any equivalent argument received full credit.)

Solution	Distribution of Points
(b) 3 points	
Because of the symmetry of the charge distribution, all the horizontal (x) components of the field cancel.	2 points
Thus, the field is directed downward.	1 point
(c) 6 points	
The differential electric field at point O is given by	
$dE_0 = \dfrac{dq}{4\pi\epsilon_0 R^2}$	1 point
The magnitude of the y component of the field is given by	
$dE_{0y} = dE_0 \cos\theta$	1 point
Thus,	
$dE_{0y} = \dfrac{\lambda \cos\theta \, d\theta}{4\pi\epsilon_0 R}$	2 points
(or any equivalent expression involving a different variable)	
$E_0 = \dfrac{\lambda}{4\pi\epsilon_0 R}(2)\displaystyle\int_0^{\pi/2} \cos\theta \, d\theta$	1 point
(or any other equivalent integral)	
Thus,	
$E_0 = \dfrac{\lambda}{2\pi\epsilon_0 R} = \dfrac{2k\lambda}{R}$	1 point
(d) 3 points	
The work W_P required to bring a positive point charge q from infinity to the point P is given by	
$W_P = qV_P$	
The work required to bring q from P to O is given by	
$W_{OP} = q(V_0 - V_P)$	1 point
If the field E is approximately constant between points O and P, then the work is also given by	
$W_{OP} = qE_0 s$	1 point
Thus,	
$W_P = qV_P = q(V_0 - E_0 s)$	1 point
Total	15 points

Solution | *Distribution of Points*

(a) 3 points



Straight	1 point
Evenly spaced	1 point
Directed down	1 point

(b) 7 points

Gauss's Law

$$\oint \vec{E} \cdot \vec{dA} = \oint E \cos\theta \, dA = \frac{q_{IN}}{\epsilon_0}$$ 1 point

The enclosed charge is given by

$$q_{IN} = \sigma A$$ 1 point

where A is the area of the top and bottom of the box.
The field E_{top} in the metal is zero. 1 point

The vector $\vec{dA}$ on the sides of the box is normal to the field; thus cos θ here is zero. 1 point

The field along the bottom of the box is a constant and perpendicular to the surface (i.e., parallel to the vector $\vec{dA}$). 1 point

Thus,

$$\oint \vec{E} \cdot \vec{dA} = EA = \frac{\sigma A}{\epsilon_0}$$ 1 point

And

$$E = \frac{\sigma}{\epsilon_0}$$ 1 point

(c) 5 points
The electric field is less. 2 points

The bound charge distribution in the dielectric has a net negative charge on the top surface and positive on the bottom. Thus, the combined charge is less and so is the electric field. 3 points

Total 15 points

1980 C: E&M-3

(a) 3 points
The induced current will be clockwise. 1 point

According to Lenz's law, the emf induced by a changing magnetic field will generate a current in a closed loop such that the induced magnetic field will oppose the initial change of flux. In this case, the field increases out of the page; thus, the induced field must be into the page. Thus, the induced current must be clockwise. 2 points