AP® Physics C
1981 Scoring Guidelines

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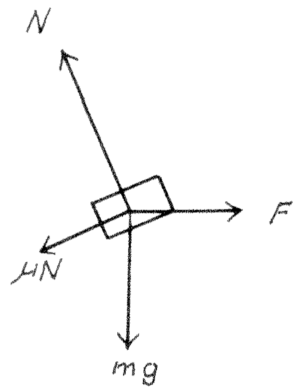
1. a) 4 points



1 point for each of the four arrows. Directions must be correct. Any reasonable label is acceptable. **4 points**

b) 7 points

$\Sigma\vec{F} = m\vec{a}$ or facsimile **1 point**

$f_k = \mu N$ or facsimile **1 point**

From summing forces perpendicular to the plane

$N = mg\cos\theta + F\sin\theta$ **1 point**

From using Newton's second law in a direction parallel to the plane

$$a_{\parallel} = \underbrace{\frac{F}{m}\cos\theta}_{\text{1 pt.}} - \underbrace{g\sin\theta}_{\text{1 pt.}} - \underbrace{\frac{\mu N}{m}}_{\text{1 pt.}}$$

or **3 points**

$$a_{\parallel} = \overbrace{\frac{F}{m}\cos\theta} - \overbrace{g\sin\theta} - \overbrace{\left(\mu g\cos\theta + \frac{\mu F}{m}\sin\theta\right)}$$

Also, for correct algebra to get expression. **1 point**

Solution	*Distribution of Points*
c) 4 points	
$v = \text{const} \Rightarrow a_{\parallel} = 0$	1 point
$\therefore F = mg\left(\dfrac{\mu\cos\theta + \sin\theta}{\cos\theta - \mu\sin\theta}\right)$	1 point
$F > 0 \Rightarrow \cos\theta > \mu\sin\theta$	1 point
$\therefore \tan\theta < \dfrac{1}{\mu}$	1 point
Total	15 points
2. 15 points	
During downswing energy is conserved	
$(2M)gh = \frac{1}{2}(2M)v^2$	2 points
with $h = L/2$	1 point
$\therefore v = \sqrt{gL}$ for speed at bottom.	1 point
During upswing energy is conserved	
$\frac{1}{2}Mv_s^2 = MgH$	2 points
with $H = L(1 - \sqrt{2}/2)$	1 point
$\therefore v_s = \sqrt{gL}\cdot(\sqrt{2 - \sqrt{2}})$ for speed of swing after child jumps	1 point
During jump momentum is conserved	3 points
$2Mv = Mv_s + Mv_c$	2 points
$v_c = \sqrt{gL}\cdot(2 - \sqrt{2 - \sqrt{2}})$	2 points
Total	15 points
3. a) 5 points	
From conservation of linear momentum	
$m_2 v = m_2\left(\dfrac{-v}{2}\right) + M_1 v'$	4 points
$v' = \dfrac{3}{2}\dfrac{m_2}{M_1}v$	1 point
b) 4 points	
From conservation of angular momentum	
ref cm	
$m_2 v\dfrac{L}{3} = m_2 \cdot \dfrac{-v}{2}\cdot\dfrac{L}{3} + \dfrac{1}{12}M_1 L^2\omega$ ref P. $0 = I\omega - M_1 v'$	3 points
$\omega = \dfrac{6\, m_2 v}{M_1 L}$	1 point
c) 6 points	
$\Delta K = KE_{\text{final}} - KE_{\text{orig}}$	2 points
$= \frac{1}{2}m_2\dfrac{v^2}{4} + \frac{1}{2}I\omega^2 + \frac{1}{2}M_1(v')^2 - \frac{1}{2}m_2 v^2$	3 points
$= \dfrac{3}{8}m_2 v^2 - \dfrac{21}{8}\dfrac{m_2^2}{M_1}v^2$	1 point
Total	15 points

Solution	*Distribution of Points*
1. a) 6 points	
For statement of Gauss's law	
$\oiint \vec{E} \cdot d\vec{A} = \frac{Q}{\epsilon_o}$	3 points
There must be a clear indication that a scalar product of vectors is involved in the integrand.	
Sketch of spherical Gaussian surface *or* sketch of radial $\vec{E}$ field *or* statement that $\vec{E}$ is parallel to $\vec{ds}$.	1 point
$\int E ds = \frac{Q}{\epsilon_o}$	
$E \int ds = \frac{Q}{\epsilon_o}$	
$\int ds = 4\pi r^2$	1 point
$\therefore E = \frac{Q}{4\pi\epsilon_o r^2}$	1 point
b) 5 points	
$C = \left\| \frac{Q}{V} \right\|$	2 points
$V = -\int_a^b \vec{E} \cdot \vec{dl} = \frac{Q}{4\pi\epsilon_o r}\Big\|_a^b$ (or recognizing V from $\vec{E}$)	1 point
$V = \frac{Q}{4\pi\epsilon_o}\left(\frac{1}{b} - \frac{1}{a}\right)$	1 point
$\therefore C_o = 4\pi\epsilon_o\left(\frac{ab}{b-a}\right)$	1 point
c) 4 points	
Consider the system as two capacitors in parallel	
$C_{top} = \frac{C_o}{2}$	1 point
$C_{bottom} = \frac{C_o}{2} \times 4$	2 points
$C_{total} = C_{top} + C_{bottom} = \frac{5}{2} C_o$	1 point
Total	15 points
2. a) 2 points	
$\vec{E}$ to the right	1 point
$\vec{E}$ axial	1 point

Solution	*Distribution of Points*
c) 4 points	
$v = \text{const} \Rightarrow a_{\parallel} = 0$	1 point
$\therefore F = mg\left(\dfrac{\mu\cos\theta + \sin\theta}{\cos\theta - \mu\sin\theta}\right)$	1 point
$F > 0 \Rightarrow \cos\theta > \mu\sin\theta$	1 point
$\therefore \tan\theta < \dfrac{1}{\mu}$	1 point
Total	15 points
2. 15 points	
During downswing energy is conserved	
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$\therefore v_s = \sqrt{gL}\cdot(\sqrt{2-\sqrt{2}})$ for speed of swing after child jumps	1 point
During jump momentum is conserved	3 points
$2Mv = Mv_s + Mv_c$	2 points
$v_c = \sqrt{gL}\cdot(2 - \sqrt{2-\sqrt{2}})$	2 points
Total	15 points
3. a) 5 points	
From conservation of linear momentum	
$m_2v = m_2\left(\dfrac{-v}{2}\right) + M_1v'$	4 points
$v' = \dfrac{3}{2}\dfrac{m_2}{M_1}v$	1 point
b) 4 points	
From conservation of angular momentum	
ref cm $m_2v\dfrac{L}{3} = m_2\cdot\dfrac{-v}{2}\cdot\dfrac{L}{3} + \dfrac{1}{12}M_1L^2\omega$ ref P. $0 = I\omega - M_1v'$	3 points
$\omega = \dfrac{6\,m_2v}{M_1L}$	1 point
c) 6 points	
$\Delta K = KE_{\text{final}} - KE_{\text{orig}}$	2 points
$= \frac{1}{2}m_2\dfrac{v^2}{4} + \frac{1}{2}I\omega^2 + \frac{1}{2}M_1(v')^2 - \frac{1}{2}m_2v^2$	3 points
$= \dfrac{3}{8}m_2v^2 - \dfrac{21}{8}\dfrac{m_2^2}{M_1}v^2$	1 point
Total	15 points

b) 5 points

$$dE = \frac{1}{4\pi\epsilon_o}\,\frac{dQ}{a^2 + b^2}$$ 1 point

$$dE_x = \frac{1}{4\pi\epsilon_o}\,\frac{dQ}{a^2 + b^2}\cdot\cos\theta$$ 1 point

$$= \frac{1}{4\pi\epsilon_o}\,\frac{dQ}{a^2 + b^2}\cdot\frac{b}{\sqrt{a^2 + b^2}}$$ 1 point

$$E = \int dE_x$$ 1 point

$$= \frac{1}{4\pi\epsilon_o}\,\frac{bQ}{(a^2 + b^2)^{3/2}}$$ 1 point

c) 2 points

$$I = \frac{Q\omega}{2\pi}$$ 2 points

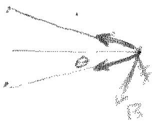
d) 2 points

$\vec{B}$ to the left 1 point

$\vec{B}$ axial 1 point

e) 4 points

From Biot-Savart law,



sin ~~cos~~θ is only component that adds,
$= \frac{a}{\sqrt{a^2+b^2}}$

$$dB = \frac{\mu_o\, I\,[a\, d\theta]}{4\pi\,(a^2 + b^2)}$$ 2 points

$$dB_x = dB\cdot\frac{a}{\sqrt{a^2 + b^2}}$$ 1 point

$$B = \frac{\mu_o\,\omega a^2\, Q}{4\pi\,(a^2 + b^2)^{3/2}}$$ 1 point

Total 15 points

3. a) 3 points

arrow or statement for counterclockwise 3 points

b) 5 points

The induced emf $\mathcal{E}$ by Faraday's law is

$$\mathcal{E} = \frac{-d\Phi_B}{dt}$$ 2 points

where $\Phi_B = B\cdot A$ 1 point

and $A = s\,(s - x)$ 1 point

so, $\mathcal{E} = B\cdot s\cdot v$ 1 point

Solution	Distribution of Points
c) 3 points	
From definition of R,	
$i = \frac{\mathcal{E}}{R}$	2 points
$i = \frac{Bsv}{R}$	1 point
d) 4 points	
$P = \mathcal{E}i = \frac{\mathcal{E}^2}{R} = i^2 \cdot R$	3 points
$P = \frac{B^2s^2v^2}{R}$	1 point
Alternate method:	*Alternate Points*
$P = F \cdot v$	(1 point)
where $F = Bis$	(2 points)
so, $P = \frac{B^2s^2v^2}{R}$	(1 point)
Total	15 points