



AP[®] Physics C 1981 Scoring Guidelines

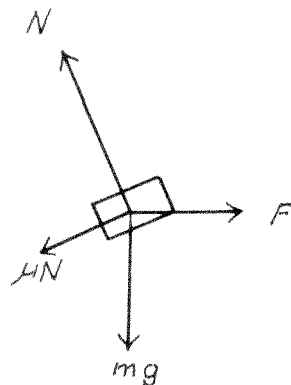
The materials included in these files are intended for use by AP teachers for course and exam preparation in the classroom; permission for any other use must be sought from the Advanced Placement Program[®]. Teachers may reproduce them, in whole or in part, in limited quantities, for face-to-face teaching purposes but may not mass distribute the materials, electronically or otherwise. These materials and any copies made of them may not be resold, and the copyright notices must be retained as they appear here. This permission does not apply to any third-party copyrights contained herein.

These materials were produced by Educational Testing Service[®] (ETS[®]), which develops and administers the examinations of the Advanced Placement Program for the College Board. The College Board and Educational Testing Service (ETS) are dedicated to the principle of equal opportunity, and their programs, services, and employment policies are guided by that principle.

The College Board is a national nonprofit membership association dedicated to preparing, inspiring, and connecting students to college and opportunity. Founded in 1900, the association is composed of more than 4,200 schools, colleges, universities, and other educational organizations. Each year, the College Board serves over three million students and their parents, 22,000 high schools, and 3,500 colleges, through major programs and services in college admission, guidance, assessment, financial aid, enrollment, and teaching and learning. Among its best-known programs are the SAT[®], the PSAT/NMSQT[®], and the Advanced Placement Program[®] (AP[®]). The College Board is committed to the principles of equity and excellence, and that commitment is embodied in all of its programs, services, activities, and concerns.

Copyright © 2002 by College Entrance Examination Board. All rights reserved. College Board, Advanced Placement Program, AP, SAT, and the acorn logo are registered trademarks of the College Entrance Examination Board. APIEL is a trademark owned by the College Entrance Examination Board. PSAT/NMSQT is a registered trademark jointly owned by the College Entrance Examination Board and the National Merit Scholarship Corporation. Educational Testing Service and ETS are registered trademarks of Educational Testing Service.

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

$$\Sigma \vec{F} = m\vec{a} \text{ or facsimile}$$

1 point

$$f_k = \mu N \text{ or facsimile}$$

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

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

$$\text{or } a_{||} = \underbrace{\frac{F}{m} \cos \theta}_{1 \text{ pt.}} - \underbrace{g \sin \theta}_{1 \text{ pt.}} - \underbrace{(\mu g \cos \theta + \frac{\mu F}{m} \sin \theta)}_{1 \text{ pt.}}$$

3 points

$$a_{||} = \frac{F}{m} \cos \theta - g \sin \theta - (\mu g \cos \theta + \frac{\mu F}{m} \sin \theta)$$

Also, for correct algebra to get expression.

1 point

Solution

Distribution of Points

c) 4 points

$$v = \text{const} \Rightarrow a_{11} = 0$$

1 point

$$\therefore F = mg \left(\frac{\mu \cos \theta + \sin \theta}{\cos \theta - \mu \sin \theta} \right)$$

1 point

$$F > 0 \Rightarrow \cos \theta > \mu \sin \theta$$

1 point

$$\therefore \tan \theta < \frac{1}{\mu}$$

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

$$\therefore v = \sqrt{gL} \text{ for speed at bottom.}$$

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

$$\therefore v_s = \sqrt{gL} \cdot (\sqrt{2} - \sqrt{2}) \text{ for speed of swing after child jumps}$$

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

$$m_2 v = m_2 \left(\frac{-v}{2} \right) + M_1 v'$$

4 points

$$v' = \frac{3}{2} \frac{m_2}{M_1} v$$

1 point

b) 4 points

From conservation of angular momentum

$$m_2 v \frac{L}{3} = m_2 \cdot \frac{-v}{2} \cdot \frac{L}{3} + \frac{1}{12} M_1 L^2 \omega$$

3 points

$$\omega = \frac{6 m_2 v}{M_1 L}$$

1 point

c) 6 points

$$\Delta K = KE_{\text{final}} - KE_{\text{orig}}$$

2 points

$$= \frac{1}{2} m_2 \frac{v^2}{4} + \frac{1}{2} I \omega^2 + \frac{1}{2} M_1 (v')^2 - \frac{1}{2} m_2 v^2$$

3 points

$$= \frac{3}{8} m_2 v^2 - \frac{21}{8} \frac{m_2^2}{M_1} v^2$$

1 point

Total 15 points

1. a) 6 points

For statement of Gauss's law

$$\oint \vec{E} \cdot d\vec{A} = \frac{Q}{\epsilon_0}$$

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 $d\vec{s}$.

1 point

$$\int E ds = \frac{Q}{\epsilon_0}$$

$$E \int ds = \frac{Q}{\epsilon_0}$$

$$\int ds = 4\pi r^2$$

1 point

$$\therefore E = \frac{Q}{4\pi\epsilon_0 r^2}$$

1 point

b) 5 points

$$C = \left| \frac{Q}{V} \right|$$

2 points

$$V = - \int_a^b \vec{E} \cdot d\vec{l} = \frac{Q}{4\pi\epsilon_0 r} \Big|_a^b \text{ (or recognizing } V \text{ from } \vec{E})$$

1 point

$$V = \frac{Q}{4\pi\epsilon_0} \left(\frac{1}{b} - \frac{1}{a} \right)$$

1 point

$$\therefore C_0 = 4\pi\epsilon_0 \left(\frac{ab}{b-a} \right)$$

1 point

c) 4 points

Consider the system as two capacitors in parallel

$$C_{\text{top}} = \frac{C_0}{2}$$

1 point

$$C_{\text{bottom}} = \frac{C_0}{2} \times 4$$

2 points

$$C_{\text{total}} = C_{\text{top}} + C_{\text{bottom}} = \frac{5}{2} C_0$$

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

$$v = \text{const} \Rightarrow a_{11} = 0$$

1 point

$$\therefore F = mg \left(\frac{\mu \cos \theta + \sin \theta}{\cos \theta - \mu \sin \theta} \right)$$

1 point

$$F > 0 \Rightarrow \cos \theta > \mu \sin \theta$$

1 point

$$\therefore \tan \theta < \frac{1}{\mu}$$

1 point

Total 15 points

2. 15 points

During downswing energy is conserved

$$(2M)gh = \frac{1}{2}(2M)v^2$$

2 points

$$\text{with } h = L/2$$

1 point

$$\therefore v = \sqrt{gL} \text{ for speed at bottom.}$$

1 point

During upswing energy is conserved

$$\frac{1}{2}Mv_s^2 = MgH$$

2 points

$$\text{with } H = L(1 - \sqrt{2}/2)$$

1 point

$$\therefore v_s = \sqrt{gL} \cdot (\sqrt{2} - \sqrt{2}) \text{ for speed of swing after child jumps}$$

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

$$m_2v = m_2 \left(\frac{-v}{2} \right) + M_1v'$$

4 points

$$v' = \frac{3}{2} \frac{m_2}{M_1} v$$

1 point

b) 4 points

From conservation of angular momentum

$$m_2v \frac{L}{3} = m_2 \cdot \frac{-v}{2} \cdot \frac{L}{3} + \frac{1}{12} M_1 L^2 \omega$$

3 points

$$\omega = \frac{6 m_2 v}{M_1 L}$$

1 point

c) 6 points

$$\Delta K = KE_{\text{final}} - KE_{\text{orig}}$$

2 points

$$= \frac{1}{2}m_2 \frac{v^2}{4} + \frac{1}{2}I\omega^2 + \frac{1}{2}M_1(v')^2 - \frac{1}{2}m_2v^2$$

3 points

$$= \frac{3}{8}m_2v^2 - \frac{21}{8} \frac{m_2^2}{M_1} v^2$$

1 point

Total 15 points

b) 5 points

$$dE = \frac{1}{4\pi\epsilon_0} \frac{dQ}{a^2 + b^2} \quad 1 \text{ point}$$

$$dE_x = \frac{1}{4\pi\epsilon_0} \frac{dQ}{a^2 + b^2} \cdot \cos \theta \quad 1 \text{ point}$$

$$= \frac{1}{4\pi\epsilon_0} \frac{dQ}{a^2 + b^2} \cdot \frac{b}{\sqrt{a^2 + b^2}} \quad 1 \text{ point}$$

$$E = \int dE_x \quad 1 \text{ point}$$

$$= \frac{1}{4\pi\epsilon_0} \frac{bQ}{(a^2 + b^2)^{3/2}} \quad 1 \text{ point}$$

c) 2 points

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

d) 2 points

\vec{B} to the left 1 point

\vec{B} axial 1 point

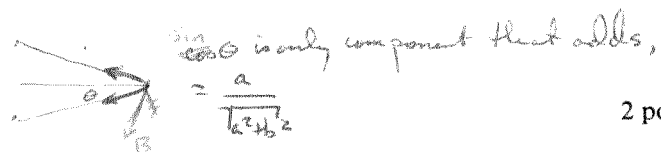
e) 4 points

From Biot-Savart law,

$$dB = \frac{\mu_0 I [a \, d\theta]}{4\pi (a^2 + b^2)} \quad 2 \text{ points}$$

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

$$B = \frac{\mu_0 \omega a^2 Q}{4\pi (a^2 + b^2)^{3/2}} \quad 1 \text{ point}$$



 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

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

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,

$$i = \frac{\mathcal{O}}{R}$$

2 points

$$i = \frac{Bsv}{R}$$

1 point

d) 4 points

$$P = \mathcal{O}i = \frac{\mathcal{O}^2}{R} = i^2 \cdot R$$

3 points

$$P = \frac{B^2 s^2 v^2}{R}$$

1 point

Alternate method:

$$P = F \cdot v$$

*Alternate
Points*

(1 point)

where $F = Bis$

(2 points)

$$\text{so, } P = \frac{B^2 s^2 v^2}{R}$$

(1 point)

Total 15 points