AP® Physics C
1986 Scoring Guidelines

SOLUTION

Distribution of points

Mech 1.

(a) 4 points

Considering the forces on the person and platform,

$\Sigma F = 0$ — 1 point

$2T = (80 \text{ kg} + 20 \text{ kg})(10 \text{ m/s}^2) = 1000 \text{ N}$ — 2 points

$T = 500 \text{ N}$ — 1 point

(b) 4 points

Again considering the forces on the person and platform,

$\Sigma F = ma$

$\underbrace{2T}_{1 \text{ pt.}} - \underbrace{1000 \text{ N}}_{1 \text{ pt.}} = \underbrace{(100\text{kg})(2 \text{ m/s}^2)}_{1 \text{ pt.}}$ — 3 points

$T = 600 \text{ N}$ — 1 point

(c) 5 points

Considering the forces on the person only, $\Sigma F = ma$

$\underbrace{\text{Normal}}_{1 \text{ pt.}} + \underbrace{600 \text{ N}}_{1 \text{ pt.}} - \underbrace{(80 \text{ kg})(10 \text{ m/s}^2)}_{1 \text{ pt.}} = \underbrace{(80 \text{ kg})(2 \text{ m/s}^2)}_{1 \text{ pt.}}$ — 4 points

$\text{Normal} = 360 \text{ N}$ — 1 point

(d) 2 points

$P = \frac{\text{work}}{\text{time}} = \frac{mgh}{t} = (mg)v$ — 1 point

$P = (1000 \text{ N})(0.4 \text{ m/s}) = 400 \text{ W}$ — 1 point

Physics C

Mech 2.

(a) 6 points

P.E. = K.E. 1 point

$$\underbrace{Mgh}_{1\text{ pt.}} = \underbrace{\tfrac{1}{2}Mv^2 + \tfrac{1}{2}I\omega^2}_{1\text{ pt.}}$$ 2 points

$\omega = v/R$ 1 point

$$Mgh = \tfrac{1}{2}Mv^2 + \tfrac{1}{2}\left(\tfrac{2}{5}MR^2\right)\left(\tfrac{v}{R}\right)^2$$

$$= \tfrac{1}{2}Mv^2 + \tfrac{1}{5}Mv^2 = \tfrac{7}{10}Mv^2$$

$$v^2 = \tfrac{10}{7}gh$$

i. $K_{trans} = \tfrac{1}{2}Mv^2 = \tfrac{5}{7}Mgh$ 1 point

ii. $K_{rot} = \tfrac{1}{2}I\omega^2 = \tfrac{1}{5}Mv^2 = \tfrac{2}{7}Mgh$ 1 point

(b) 6 points

i. $v^2 = 2as$ 1 point

$$a = \frac{v^2}{2s} = \frac{(10/7)\ gh}{2(h/\sin\ \theta)} = \frac{5}{7}\ g\ \sin\ \theta$$ 1 point

Alternate Solutions

(Alternate Points)

Method 1:

Summing the forces parallel to the plane, (1 point)

$\Sigma\ F = ma$

$Mg\ \sin\ \theta - f = Ma$

$f = \dfrac{I\alpha}{R} = \tfrac{2}{5}Ma$

$Mg\ \sin\ \theta - \tfrac{2}{5}Ma = Ma$

$a = \tfrac{5}{7}g\ \sin\ \theta$ (1 point)

Physics C

Mech. 2. (b) i. (alternate solutions continued)

Method 2:

Summing the torques about the point of contact,

$\Sigma \Gamma = I\alpha$ (1 point)

$$\alpha = \frac{(Mg \sin \theta)R}{MR^2 + \frac{2}{5}MR^2} = \frac{g \sin \theta}{\frac{7}{5}R}$$

$a = \alpha R$

$a = \frac{5}{7}g \sin \theta$ (1 point)

ii. $\Gamma = I\alpha$ 1 point

$\Gamma = fR$ 1 point

$$f = \frac{I\alpha}{R} = \left(\frac{2}{5}MR^2\right)\frac{\alpha}{R} = \frac{2}{5}MR\alpha$$

but $\alpha = \frac{a}{R}$, 1 point

$$\text{so } f = \frac{2}{5}MR\frac{a}{R} = \frac{2}{5}M\left(\frac{5}{7}g \sin \theta\right)$$

$f = \frac{2}{7}Mg \sin \theta$ 1 point

Alternate Solution (Alternate Points)

$\Sigma F = ma$ (1 point)

$Mg \sin \theta - f = Ma$ (1 point)

$$\left.\begin{aligned} F &= Mg \sin \theta - M\left(\frac{5}{7}g \sin \theta\right) \\ f &= \frac{2}{7}Mg \sin \theta \end{aligned}\right\}$$ (2 points)

(c) 1 point

$K_{tot} = mgh$ 1 point

(d) 2 points

The rotational kinetic energy of the hollow sphere is greater than for the solid sphere, 1 point

because the moment of inertia is greater. 1 point

Physics C

Mech 3.

(a) 4 points

$F = -\frac{dU}{dx}$ or $U = -\int F(x)\,dx$ — 1 point

$U = -\int_0^A (-kx^3)\,dx$ — 1 point

$U = \frac{kx^4}{4}\Big]_0^A$ — 1 point

$U = \frac{kA^4}{4}$ — 1 point

(b) 4 points

From conservation of energy, maximum kinetic energy equals potential energy at point of release

$\frac{1}{2}Mv_{max}^2 = \frac{1}{4}kA^4$ — 2 points

$v_{max}^2 = \frac{kA^4}{2M}$ — 1 point

$v_{max} = A^2\sqrt{\frac{k}{2M}}$ — 1 point

(c) 4 points

From conservation of energy, $E_{tot} = K + U$

when $K = U$, $E_{tot} = U + U = 2U$

$U = \frac{1}{2}E_{tot}$

$\frac{kx^4}{4} = \frac{1}{2}\left(\frac{kA^4}{4}\right)$ — 3 points

$x = \frac{A}{2^{1/4}}$ — 1 point

(d) 3 points

The period of oscillation decreases — 1 point

For a spring that obeys Hooke's law, $F \propto x$, and the period is independent of amplitude. For the spring in this problem, $F \propto x^3$, so the force and hence acceleration increase at a greater rate with displacement than for the Hooke's law spring. — 2 points

or

For a Hooke's law spring $v_{max} \propto A$, and

$T \propto \frac{A}{v_{max}}$ = constant.

For the spring in the problem, from part (b),

$v_{max} \propto A^2$, and $T \propto \frac{A}{v_{max}} \propto \frac{1}{A}$

Physics C

E&M 1.

(a) 3 points

All vectors drawn with correct sense (higher to lower potential)	1 point
All vectors drawn perpendicular to equipotential lines	1 point
For showing vectors at all three points (−1 point for missing vectors)	1 point

(b) 2 points

Magnitude of electric field is greatest at point T,	1 point
because equipotential lines are closest together near T.	1 point

(Note: Some students misinterpreted the question to mean at which of the points L, N, and V, from part (a), is the field greatest. For these students, an answer of point U received credit.)

(c) 4 points

$E = \frac{\Delta V}{\Delta x}$	1 point
For correct substitutions	
$\Delta V = 10$ V	1 point
$\Delta x = .02$ m	1 point
$E = 500$ V/m	1 point

(d) 2 points

$V_m - V_s = 40\text{ V} - 5\text{ V} = 35\text{ V}$	2 points

(Note: deviation of ±2 in the answer was acceptable)

(e) 3 points

$W = q\Delta V$	
$W = (5 \times 10^{-12}\text{ C})\ (40\text{ V} - 30\text{ V})$	1 point
$W = 5 \times 10^{-11}$ J	2 points

(f) 1 point

No, <u>or</u> Same, <u>or</u> Same as (a), <u>or</u> Work does not depend on path	1 point

Physics C

E&M 2.

(a) 4 points

$V = IR$ 1 point

For correctly obtaining 20 Ω as the resistance of the combination of 10 Ω and 30 Ω resistors 1 point

$R_T = 5\ \Omega + 20\ \Omega = 25\ \Omega$ 1 point

$I_T = \frac{25\ \text{V}}{25\ \Omega} = 1\ \text{A}$

$I_R = \frac{1}{2}I_T = \frac{1}{2}\ \text{A}$ 1 point

(b) 2 points

$I_R = \frac{1}{2}\ \text{A}$ or same as in part (a) 2 points

(c) 4 points

$Q = C\Delta V$ 1 point

$\Delta V = 10V$ 2 points

$Q = 100\ \mu\text{C}$ 1 point

(d) 4 points

In the static situation, there is no potential difference across the inductor; the situation is the same as if the inductor were a resistanceless wire.

$$\left.\begin{aligned} \frac{1}{R_{||}} &= \frac{1}{10\ \Omega} + \frac{1}{30\ \Omega} \\ R_{||} &= 7.5\ \Omega \end{aligned}\right\}$$ 1 point

$R_T = 5 + 2(7.5) = 20\ \Omega$ 1 point

$I_T = \frac{25\ \text{V}}{20\ \Omega} = \frac{5}{4}\ \text{A}$ 1 point

$I_R = \frac{3}{4}I_T = \frac{15}{16}\ \text{A} = 0.9375\ \text{A}$ 1 point

(e) 1 point

The current through each 30 Ω resistor is $\frac{3}{4}I_T$.

Since $\Sigma\ I = 0$ at point A,

$I_L = I_{30} - I_R = \frac{3}{4}I_T - \frac{1}{4}I_T = \frac{1}{2}\left(\frac{5}{4}\ \text{A}\right)$

$I_L = \frac{5}{8}\ \text{A} = 0.624\ \text{A}$ 1 point

Physics C

E&M 3.

(a) 3 points

$\oint \mathbf{B} \cdot d\boldsymbol{\ell} = \mu_0 I$, where $I = cT$

$B = \dfrac{\mu_0 I}{2\pi r}$ — 2 points

$B = \dfrac{\mu_0 ct}{2\pi r}$ — 1 point

(b) 1 point

Induced current in loops is counterclockwise — 1 point

(c) 7 points

$\Phi_B = \int \mathbf{B} \cdot d\mathbf{S}$ — 2 points

$\Phi_B = \int_a^{b+a} \dfrac{\mu_0 I}{2\pi r}\, b\,dr$ — 1 point

$\Phi_B = \dfrac{\mu_0 Ib}{2\pi} \ln\left(\dfrac{a+b}{a}\right)$, $I = ct$ — 1 point

$\mathcal{E} = -N \dfrac{d\Phi}{dt}$ (Note: sign ignored in grading. Magnitude of $\mathcal{E}$ was all that was required.) — 1 point

$\mathcal{E} = (1) \dfrac{d}{dt}\left[\dfrac{\mu_0 ct\ b}{2\pi} \ln\left(\dfrac{a+b}{a}\right)\right]$

$\mathcal{E} = \dfrac{\mu_0 cb}{2\pi} \ln\left(\dfrac{a+b}{a}\right)$ — 1 point

$i = \dfrac{\mathcal{E}}{R} = \dfrac{\mu_0 cb}{2\pi R} \ln\left(\dfrac{a+b}{a}\right)$ — 1 point

(d) 1 point

Force on the loop is away from the wire. However, the point was awarded only if (d) was consistent with (b). If (b) was incorrect (i.e., clockwise), but (d) was consistent (force toward wire), credit was given. — 1 point

(e) 3 points

$\mathbf{F} = I\boldsymbol{\ell}\times\mathbf{B}$ — 1 point

For recognition that $F_{net} = F_a - F_{b+a}$ — 1 point

$F_{net} = I\ell B_a - I\ell B_{b+a} = I\ell(B_a - B_{b+a})$

For correct substitutions for:

I, from part (c)
B, from part (a) for $r = a$ and $r = b + a$
ℓ, using ℓ = length of side of loop = b
— 1 point

$F_{net} = \left[\dfrac{\mu_0^2 c^2 b^2 t}{4\pi^2 R} \ln\left(\dfrac{a+b}{a}\right)\right]\left(\dfrac{1}{a} - \dfrac{1}{a+b}\right)$