AP® Physics C
1977 Scoring Guidelines

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Solution	Distribution of Points
a) 3 points	
$W = \Delta KE$	2
$W = -\frac{1}{2} m v_0^2$	1
b) 3 points	
$\vec{F} = m\vec{a}$	1
$\vec{F} = -k\vec{v}$	1
$a = -\dfrac{k\vec{v}}{m}$	1
c) 5 points	
$\dfrac{dv}{v} = -\dfrac{k}{m} dt$	1
$\ln v = -\dfrac{k}{m} t + K$	2
where $K = \ln v_0$	1
Thus, $v = v_0 e^{-(k/m)t}$	1
(or correct application of limits)	

d) 4 points

$$\frac{ds}{dt} = v_0 e^{-(k/m)t} \text{ or } ds = v_0 e^{-(k/m)t}\,dt \qquad 1$$

$$s = -\frac{mv_0}{k} e^{-(k/m)t} + K$$

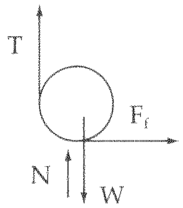
where $K = mv_0/k$ 2

$$\text{Thus, } s = \frac{mv_0}{k}[1 - e^{-(k/m)t}]$$

as $t \to \infty$, $s \to mv_0/k$ 1

1977 C: Mech.-2

	Solution	*Distribution of Points*
a) 4 points	T = tension in string N = normal force of surface W = weight of cylinder F_f = frictional force	1 point for each force whose direction was correctly shown



b) 5 points

$N = W - T = Mg - \frac{3}{5}Mg = \frac{2}{5}Mg$	1
$F_f = \mu N = \frac{1}{2} \cdot \frac{2}{5}Mg = \frac{1}{5}Mg$	1
F_f is the force which causes horizontal acceleration.	1
$a = \frac{F_f}{M} = \frac{\frac{1}{5}Mg}{M} = \frac{1}{5}g$	1
The above points were awarded even if previous steps were incorrect or if algebra was wrong; a fifth point was awarded for correct algebra leading to a multiple of g as an answer.	1

c) 4 points

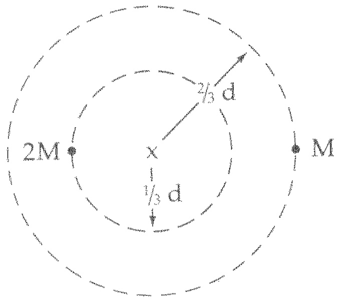
$\alpha = \frac{\tau}{I}$	1
$\tau = \tau_{string} - \tau_{friction}$	1
$\tau = FR$ (whatever force was used)	1
$I = \frac{1}{2}MR^2$ and correct algebra	1
$\alpha = \frac{4}{5}g/R$	

d) 2 points

$a \neq \alpha R$ because the cylinder *slips* on the surface	2
(because energy is lost due to friction)	1

1977 C: Mech.-3

Solution	*Distribution of Points*
a) 5 points	
$F_g = \dfrac{GMM}{(2R)^2}$	2
$F_c = \dfrac{Mv^2}{R}$	1
$F_g = F_c \Longrightarrow \dfrac{GMM}{4R^2} = \dfrac{Mv^2}{R}$	1
$v = \dfrac{1}{2}\sqrt{\dfrac{GM}{R}}$	1
b) 5 points	
$E_T = PE + KE$	1
$KE = 2(\tfrac{1}{2}Mv^2)$	1
$= \dfrac{M}{4}\sqrt{\dfrac{GM}{R}}^{\,2} = \dfrac{GM^2}{4R}$	1
$PE = -\dfrac{GMM}{2R}$	1
$E_T = \dfrac{GM^2}{4R} - \dfrac{GM^2}{2R} = -\dfrac{GM^2}{4R}$	1
c) 3 points	
Center of mass	1
Circles	1
Concentric	1



d) 2 points	
$F_{G2m} = F_{Gm}$	
$\left.\dfrac{2Mv_{2m}^2}{\tfrac{1}{3}d} = \dfrac{Mv_m^2}{\tfrac{2}{3}d}\right\}$	1
$\dfrac{v_2}{v_1} = \dfrac{1}{2}$	1
Alternate:	
$\omega_1 = \omega_2$	
$R_2v_2 = R_1v_1$	1
$\dfrac{v_2}{v_1} = \dfrac{1}{2}$	1

Alternate:

$T_1 = T_2$

$$\frac{v_2}{v_1} = \frac{2\pi R_2}{2\pi R_1}$$ 1

$$\frac{v_2}{v_1} = \frac{\frac{1}{3}d}{\frac{2}{3}d} = \frac{1}{2}$$ 1

1977 C: E&M-1

Solution	*Distribution of Points*

a) 4 points

Since all parts of the ring are at the same distance from P,

$$V = \frac{kQ}{\sqrt{R^2 + x^2}}$$

Positive quantity including kQ or Q/ϵ_0	1
Dimensionally correct answer	1
Use of $\sqrt{R^2 + x^2}$ as the relevant distance	1
Correct magnitude of answer	1

If students did c) first, then used $V = -\int \vec{E} \cdot d\vec{l}$, the result was graded by these same criteria.

b) 2 points

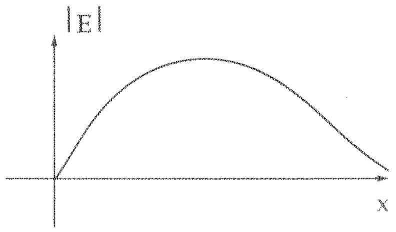
V is maximum at $x = 0$ where $\sqrt{R^2 + x^2}$ is smallest. 2

c) 5 points

$$E = \frac{kQ}{r^2}\cos\theta = \frac{kQ}{R^2 + x^2} \cdot \frac{x}{\sqrt{x^2 + R^2}} = \frac{kQx}{(R^2 + x^2)^{3/2}} \text{ directed to right}$$

Inverse-square	1
$r^2 = R^2 + x^2$	1
Taking x-component (any indication)	1
$\cos\theta = \frac{x}{\sqrt{x^2 + R^2}}$	1
Stating direction (words or a diagram)	1

d) 4 points



$\lvert E \rvert = 0$ at $x = 0$	1
Negative 2nd derivative to beyond maximum	1
Showing a maximum and inflection point beyond it	1
$\lvert E \rvert \rightarrow 0$ as $x \rightarrow \infty$	1

1977 C: E&M-2

Solution	*Distribution of Points*
a) 5 points	
$J = \sigma E = E/\rho$	1
$J = I/A$	1
$E = I\rho/A$	1
Thus $E_1 = I\rho/A$ and $E_2 = 3I\rho/A$	2
or	
$V = IR$	1
$V = EL$	1
$R = \rho L/A$	1
$E = I\rho/A$ Thus, $E_1 = I\rho/A$ and $E_2 = 3I\rho/A$	2
b) 5 points	
$V = V_1 + V_2$	2
$V = IR$	1
$R = \rho L/A$	1
$V = I\rho\,(l_1 + 3l_2)/A$	1
c) 5 points	
$\int \vec{E} \cdot d\vec{S} = q/\epsilon_0$	2
(Other units also given credit)	
$(E_2 - E_1)\,A = q/\epsilon_0$	1
$q = 2I\rho\epsilon_0$	1
Positive	1

Solution	Distribution of Points
3a) 5 points	
Counterclockwise	2
Explanation:	
Direction of current	1
Right hand rule or $\vec{F} = I\vec{L} \times \vec{B}$	1
Direction of force	1
b) 7 points	
$T = (N)(r)(BI\ell)$ for factor (N)	1
$= 0.06\ N \cdot m$ for factor ($r = 0.1m$)	2
for factor ($BI\ell$)	2
for the right combination of the factors	1
for the answer with units	1
Alternate:	
$F = I\ell B$	2
$= 6(.2)(.5) = .6N$	1
$\tau = Fr$	1
$= (.6N)(.1m)$	2
$= .06N \cdot m$	1
Alternate:	
$F = I\ell B \sin\theta = I\ell B$	2
$\tau = \int_0^{.2} F\,d\ell = \int_0^{.2} IB\ell\,d\ell$	2
$= \left.\frac{IB\ell^2}{2}\right\|_0^{.2} = \frac{6(.5)(.2)^2}{2}$	
$= .06\ N \cdot m$	1
c) 3 points	
Angular velocity increases	1
Decreasing acceleration and/or explanation	1
Goes to a terminal angular velocity	1
Alternate: