1. (a) $m_1v_1 + m_2v_2 = (m_1 + m_2)v'$ Initially: $v = \frac{8}{1 + 5t} = \frac{8}{1 + 5(0)} = 8 = v'$

$(1.000\text{ kg})(12\text{ m/s}) + 0 = (1.000\text{ kg} + M)(8)$

$\boxed{M = 0.500\text{ kg}}$

(b) $x = v_{xo}t = \left(\frac{8}{1 + 5t}\right)t$

$\boxed{x = \left(\frac{8t}{1 + 5t}\right)}$

(c) $F = ma = m\frac{dv}{dt}$ $v = \frac{8}{1 + 5t} = 8(1 + 5t)^{-1}$

$F = (1{,}500\text{ kg})(-1)(8)(1 + 5t)^{-2}(5) = (1{,}500)\frac{-40}{(1 + 5t)^2}$

$\boxed{F = \frac{-60{,}000}{(1 + 5t)^2}}$

(d) $J = \Delta p = mv - mv_o = (1{,}500)\left[\frac{8}{1 + 5(2)}\right] - (1{,}500)\left[\frac{8}{1 + 5(0)}\right]$

$\boxed{J = -10{,}900\ \frac{\text{kg}\cdot\text{m}}{\text{s}}}$

2. (a) $I = (4)\frac{1}{2}ML^2 = (4)\frac{1}{2}m/4r^2$

$$\boxed{I = \tfrac{1}{2}mr^2}$$

(b) $GPE_1 = TKE_2 + RKE_2$

$Mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$

$2mgh = \frac{1}{2}mv^2 + \frac{1}{2}(\frac{1}{2}mr^2)\left(\frac{v}{r}\right)^2$

$2gh = \frac{1}{2}v^2 + \frac{1}{4}v^2 = \frac{3}{4}v^2$

$$\boxed{v = \sqrt{\frac{8}{3}gh}}$$

(c) $TKE_2 + RKE_2 = EPE_3$ Note: $GPE_1 = TKE_2 + RKE_2$

$GPE_1 = EPE_3$

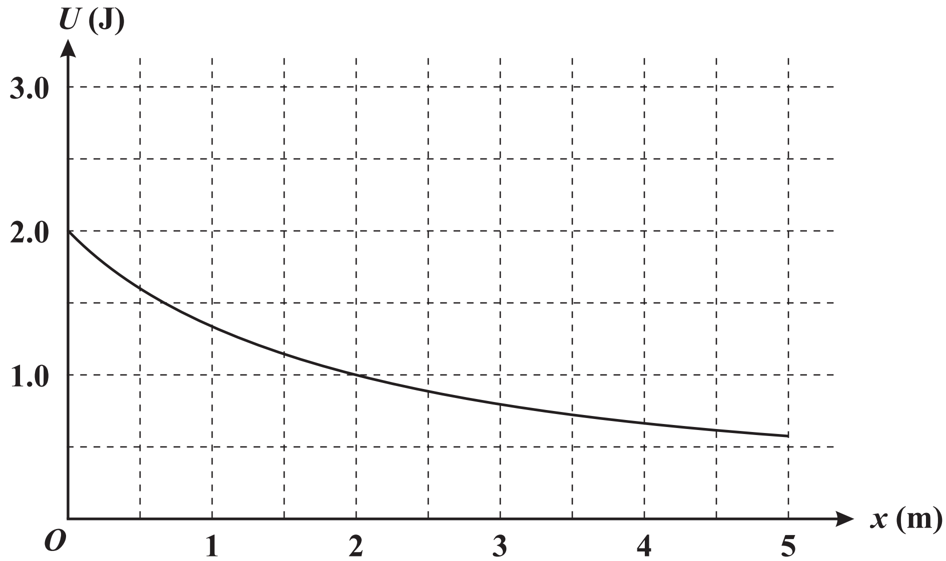
$Mgh = \frac{1}{2}kx^2$

$2mgh = \frac{1}{2}kx_m^{\ 2}$

$$\boxed{x_m = \sqrt{\frac{4mgh}{k}}} = 2\sqrt{\frac{mgh}{k}}$$

(d) Some of the energy of the collision is dissipated as heat because the collision between the cart and the spring is not perfectly elastic. The "lost" energy that would have been used to compress the spring the extra 10% of the expected value of x_m will be converted to the kinetic energy of the molecules of the spring and the cart, which will will have increased by the amount of the "lost" energy.

3. (a)



x (m)	U (J)
0	2.00
0.5	1.60
1.0	1.33
1.5	1.14
2.0	1.00
2.5	0.889
3.0	0.800
3.5	0.727
4.0	0.667
4.5	0.615
5.0	0.571

(b) By definition, U = Fx, so F can be found by taking the slope of the $U(x)$ versus x graph which is accomplished by differeniating U(x) with respect to x. U(x) can be written as $4.0(2.0 + x)^{-1}$.

$$F = \frac{dU(x)}{dx} = (-2)(4.0)(2.0 + x)^{-2}(1)$$

$$\boxed{F = \frac{-8.0}{(2.0 + x)^2}}$$

(c) $U_1 = U_2 + KE_2$

$$\frac{4.0}{2.0 + 0} = \frac{4.0}{2.0 + 2.0} + \tfrac{1}{2}(0.5\text{ kg})v^2 - 0$$

$$\boxed{v = 2.0\text{ m/s}}$$

(d) _1_ Meterstick ___ Stopwatch _1_ Photogate timer ___ String ___ Spring

___ Balance ___ Wood block ___ Set of objects of different masses

(e) Use the meterstick to measure exactly 2 meters along the air track from the origin. Place the photogate timer at this position and program the computer to measure the time the glider is passing through the photogate timer (the glider interrupts the beam of infrared light that travels from the source of the photogate timer to the photorecepter). Measure the length of the glider using the meterstick. Use the definition of average velocity ($\bar{v} = \frac{d}{t}$) to calulate the velocity at this point. There will be some experimental error since the glider will still be accelerating as its length passes through the photogate timer, and this method will calculate the average velocity of the cart during the time it is passing through the timer and not the instaneous velocity of the glider when it reaches the timer (2 meters). However, it can be assumed that the length of the glider is small compared to the distance traveled by the glider (2 meters), so the difference between the average velocity measured and the intantaneous velocity desired will be small. A picket fence can be used to rduce error.

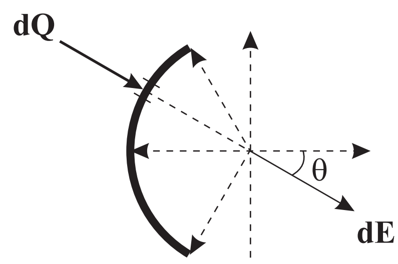
1. (a) $\lambda = \dfrac{Q}{L}$

Note: the arc spans 120° which is $\frac{1}{3}$ the circumference of a circle.

$$Q = \lambda L = Q\left(\frac{2\pi R}{3}\right) = (+1.5 \text{ x } 10^{-5} \text{ C/m})\left[\frac{2\pi(0.10 \text{ m})}{3}\right]$$

$$\boxed{Q = 3.14 \text{ x } 10^{-6} \text{ C}} = \pi \text{ x } 10^{-6} \text{ C}$$

(b) Due to the arc's symmetry, the sum of the y-components of the Electric fields from all the segments of the arc at the origin will be zero. Therefore, the direction of the net Electric field will be toward the positive x-axis.



$$dE_x = k\frac{dQ}{R^2}\cos\theta = k\frac{\lambda dL}{R^2}\cos\theta = k\frac{\lambda 2\pi R d\theta}{R^2}\cos\theta = \frac{2\pi k\lambda}{R}\cos\theta d\theta$$

$$E = E_x = \frac{2\pi k\lambda}{R}\int_{-60}^{60}\cos\theta d\theta = \frac{2\pi k\lambda}{R}\sin\theta\Big|_{-60}^{60}$$

$$E = \frac{2\pi k\lambda}{R}\left[\sin 60 - \sin(-60)\right] = \frac{2\pi k\lambda}{R}\left[\frac{\pi}{6} - \left(-\frac{\pi}{6}\right)\right] = \frac{2\pi^2 k\lambda}{3R}$$

$$E = \frac{2\pi^2 k\frac{Q}{L}}{3R} = \frac{2\pi^2 kQ}{3RL} = \frac{2\pi^2 kQ}{3R\left(\frac{2\pi R}{3}\right)} = \pi k\frac{Q}{R^2} = \pi\left(9.0 \text{ x } 10^9 \text{ N}\frac{m^2}{C^2}\right)\frac{(\pi \text{ x } 10^{-6} \text{ C})}{(0.10 \text{ m})^2}$$

$$\boxed{E = 8.9 \text{ x } 10^6 \text{ N/C}}$$

(c) $V = k\dfrac{Q}{R} = \left(9.0 \text{ x } 10^9 \text{ N}\dfrac{m^2}{C^2}\right)\dfrac{(\pi \text{ x } 10^{-6} \text{ C})}{0.10 \text{ m}}$

$$\boxed{V = 2.8 \text{ x } 10^5 \text{ V}}$$

Note: $dV = k\dfrac{dQ}{R}$. Because of the arc's symmetry, R, the distance from the representative dQ to the origin, is a constant (0.10 m) throughout the arc. Since R is a constant and the linear charge density is a constant, V, which is the sum of all dV is simply $k\dfrac{Q}{R}$, where Q is the total charge on the arc.

(d) $\Sigma F = F_e - F_a = ma$

$qE - F_a = 0$

$F_a = qE = (1.6 \text{ x } 10^{-19} \text{ C})(8.9 \text{ x } 10^6 \text{ N/C})$

$$\boxed{F_a = 1.4 \text{ x } 10^{-12} \text{ N}}$$

(e) The proton will accelerate along the positive x-axis in the positive direction. The acceleration will continually decrease over time since the electrostatic force gets weaker with an increase in distance.

2. (a) $V_0 = I_0R = (5.20 \text{ x } 10^{-3}\ \text{A})(50{,}000\ \Omega)$

$V_0 = 260$ V

(b) $\tau = RC$

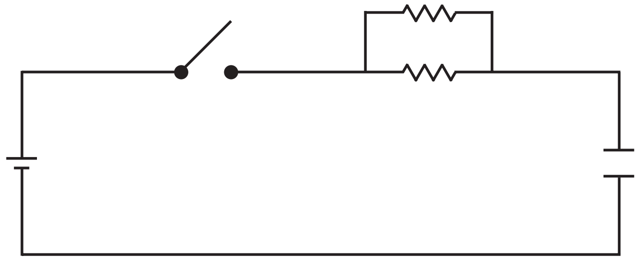
$10 = (50{,}000\ \Omega)C$

$C = 2.0 \text{ x } 10^{-4}$ F

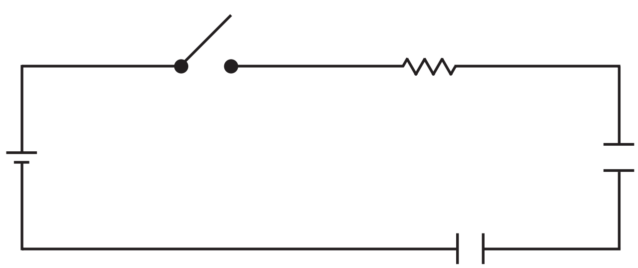
(c) i. The value of R is larger than expected, therefore, $V_0 = I_0R$ would be larger than calulated in (a) above. Since I is has been measured by the firm, its value can be considered fo be accurate.

ii. The value of the capacitance would be smaller than that predicted in (b) above. The time constant, τ, is determined from the I versus t graph (it is the time when I is 0.37 of I_0, the starting current). Sinc τ is a constant and R is larger than expected, C would be samller than expected.

(d) i.



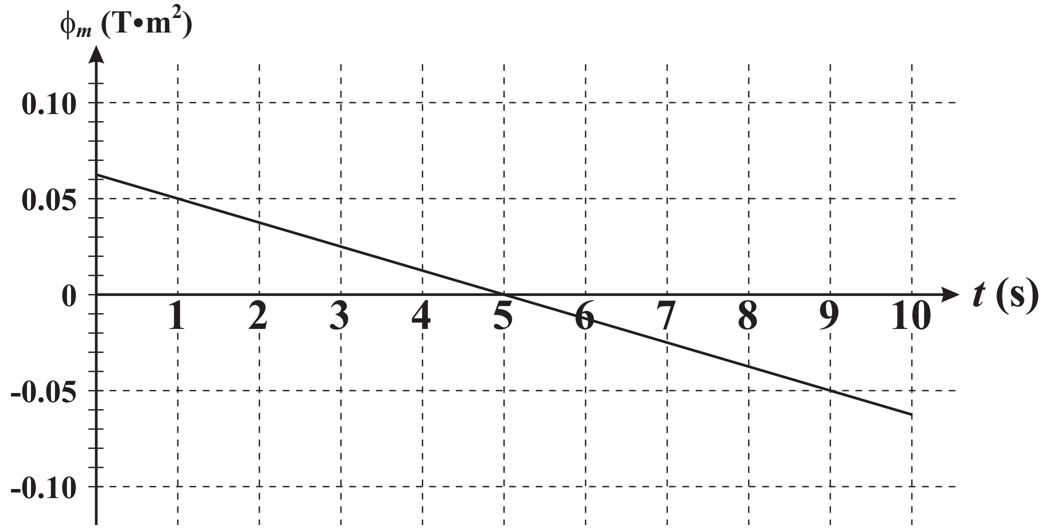
ii.



3. (a) $\phi_m = \vec{B}\cdot\vec{A} = BA\cos\theta = B\pi r^2\cos 60 = 4(1 - 0.2t)\pi r^2(0.5) = 2(1 - 0.2t)\pi(0.1\text{ m})^2$

$\boxed{\phi_m = 0.0628(1 - 0.2t)}$

(b)



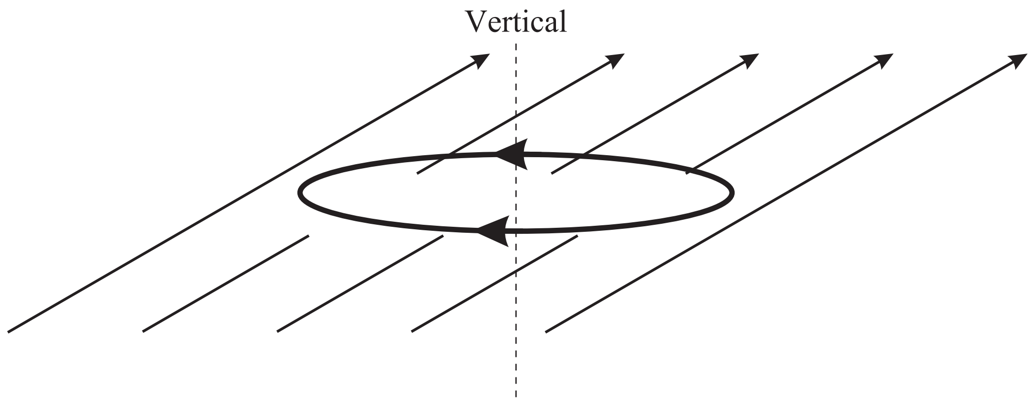
t (s)	ϕ_m (T•m²)
0	0.0628
1	0.0502
2	0.0377
3	0.0251
4	0.0126
5	0
6	-0.0126
7	-0.0251
8	-0.0377
9	-0.0502
10	-0.0628

(c) $\varepsilon = -\dfrac{d\phi_m}{dt} = \boxed{+0.0126\text{ V} = \varepsilon}$ Note: $\phi_m = 0.0628(1 - 0.2t) = 0.0628 - 0.0126t$, thus $-\dfrac{d\phi_m}{dt} = +0.0126$

(d) i. $I = \dfrac{\varepsilon}{R} = \dfrac{0.0126\text{ V}}{50\ \Omega}$

$\boxed{I = 2.51 \times 10^{-4}\text{ A}}$

ii.



(e) $P = \dfrac{E}{t} = IV$

$E = IVt = (2.51 \times 10^{-4}\text{ A})(0.0126\text{ V})(4\text{s})$

$\boxed{E = 1.27 \times 10^{-5}\text{ J}}$