1. (a) $\bar{a} = \frac{\Delta v}{\Delta t} = \frac{(-0.18 m/s - 0.22 m/s)}{(0.37 s - 0.33 s)}$

$$\boxed{\bar{a} = \frac{\Delta v}{\Delta t} = -10 \text{ m/s}^2}$$

(b) The change in momentum of the cart equals the area under the graph.

$\Delta p = \text{area} = 2(\tfrac{1}{2} b_1 h_1) + lw + 2(\tfrac{1}{2} b_2 h_2)$

$\Delta p = 2[\tfrac{1}{2}(0.01 \text{ s})(30 \text{ N})] + (0.02 \text{ s})(10 \text{ m/s}) + 2[\tfrac{1}{2}(0.01 \text{ s})(10 \text{ N})]$

$$\boxed{\Delta p = 0.6 \text{ N} \bullet \text{s} = 0.60\ kg \frac{m^2}{s}}$$

(c) $F_{net} = \frac{\Delta p}{\Delta t} = ma$

$\frac{0.60 N \bullet s}{0.04 s} = m(10 \text{ m/s}^2)$

$$\boxed{m = 1.5 \text{ kg}}$$

(d) $KE_{Lost} = \tfrac{1}{2} m v_1^2 - \tfrac{1}{2} m v_2^2 = \tfrac{1}{2}(1.5 \text{ kg})(0.22 \text{ m/s})^2 - \tfrac{1}{2}(1.5 \text{ kg})(0.18 \text{ m/s})^2$

$$\boxed{KE_{Lost} = 0.012 \text{ J}}$$

2. (a) i. $\Sigma F = F_g = F_c$

$$G\frac{M_J m_o}{R^2} = m_o\frac{v^2}{R} \quad \text{(}m_o\text{ cancels)}$$

$$V^2 = \frac{GM_J}{R}$$

$$\boxed{v = \sqrt{\frac{GM_J}{R}}}$$

ii. $v = \frac{d}{t} = \frac{2\pi R}{T}$

$$\sqrt{\frac{GM_J}{R}} = \frac{2\pi R}{T} \quad \text{(square both sides)}$$

$$\frac{GM_J}{R} = \frac{4\pi^2 R^2}{T^2} \quad \text{(cross multiply and solve for } T^2\text{)}$$

$$T^2 = \frac{4\pi^2 R^3}{GM_J}$$

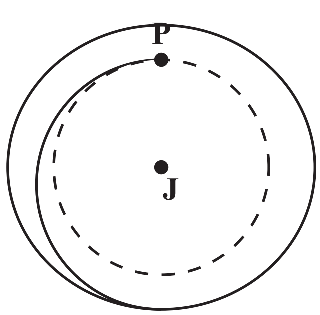
$$\boxed{T = \sqrt{\frac{4\pi^2 R^3}{GM_J}}}$$

(b) $$3.55 \times 10^4 \text{ s} = \sqrt{\frac{4\pi^2 R^3}{\left(6.67x10^{-11}\ \frac{N \bullet m^2}{kg^2}\right)\left(1.90x10^{27}\ kg\right)}} \quad \text{(square both sides)}$$

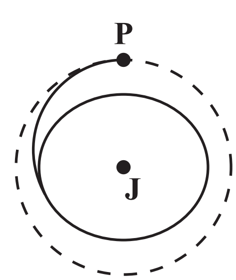
$$1.26 \times 10^9 \text{ s}^2 = \frac{4\pi^2 R^3}{\left(6.67x10^{-11}\ \frac{N \bullet m^2}{kg^2}\right)\left(1.90x10^{27}\ kg\right)} \quad \text{(solve for R)}$$

$$\boxed{R = 1.59 \times 10^8 \text{ m}}$$

(c) i. The resulting path will be an ellipse with an average radius larger than the orbit shown as the dotted line.



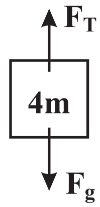
ii. The resulting path will be an ellipse with an The resulting path will be an ellipse with as the dotted line.



3. (a) $I = \Sigma m r_i^2 = mL^2 + mL^2$

$$\boxed{I = 2mL^2}$$

(b) The linear (tangential) acceleration for a point on the edge of the central pole is equal to the acceleration of the large block.



Call down poitive, and up negative.

$\Sigma F = ma_T$

$4mg - F_T = 4ma_T$

$F_T = 4mg - 4ma_T$

$F_T = 4m(g - a_T)$

$\Sigma T = I\alpha$

$rF_T\sin\theta = Ir\dfrac{a_T}{r}$ (multiply both sides by r, θ is 90° and the sin 90° is one, F = Mg = 4mg)

$r^2 4m(a_T - g) = 2mL^2 a_T$ (divide both sides by 2m)

$r^2 2(g - a_T) = L^2 a_T$

$2r^2 g - 2r^2 a_T = L^2 a_T$

$2r^2 g = L^2 a_T + 2r^2 a_T$

$$\boxed{a_T = \frac{2r^2 g}{L^2 + 2r^2}}$$

(c) __X__ Equal to 4mgD

$\Delta GPE = \Delta KE_{total}$ (the initial KE is zero and ΔGPE is 4mgD)

$$\boxed{4mgD = KE_{final}}$$

(d) __X__ Less

The blocks on the end of the string will have some gravitational potential energy. Therefore, in this situation the change in gravitational potential energy is not all converted to kinetic energy of the blocks; some is converted to the gravitational potential energy of the two blocks on the strings. Thus, the intantaneous total kinetic energy of the the three blocks will be less than that in part (c.) when the large block falls the same distance.

1. (a) $\Sigma E = E_{TC} + E_{BC} + E_{SU} + E_{DU}$

E_{TC}-Electric field from top of cloud (3 km),
E_{BC}-Electric field from bottom of cloud (2 km),
E_{SU}-Electric field from shallow underground (2 km),
E_{DU}-Electric field from deep underground (3 km).

$$\Sigma E = k\frac{Q_{TC}}{r_{TC}^2} + k\frac{Q_{BC}}{r_{BC}^2} + k\frac{Q_{SU}}{r_{SU}^2} + k\frac{Q_{DU}}{r_{DU}^2}$$

$$\Sigma E = k\left(\frac{Q_{TC}}{r_{TC}^2} + \frac{Q_{BC}}{r_{BC}^2} + \frac{Q_{SU}}{r_{SU}^2} + \frac{Q_{DU}}{r_{DU}^2}\right)$$

$$\Sigma E = (9 \times 10^9\ \text{N}\bullet\text{m}^2/\text{C}^2)\left[-\frac{30C}{(3000m)^2} + \frac{30C}{(2000m)^2} + \frac{30C}{(2000m)^2} - \frac{30C}{(3000m)^2}\right] \quad \text{(up is positive)}$$

$$\boxed{\Sigma E = 75{,}000\ \frac{N}{C}}$$

(b) i.

P_2

ii. X Less because point P_2 is farther from the point sources of charge than P_1. The sum of the x-components of the electric fields will be zero for point P_2 (as well as P_1). The sum of the y-components of the electric fields will be smaller for point P_2 than P_1 because point P_2 is farther from the point sources of charge than P_1.

(c) i. $V_{total} = k\frac{Q_{TC}}{r_{TC}} + k\frac{Q_{BC}}{r_{BC}} + k\frac{Q_{SU}}{r_{SU}} + k\frac{Q_{DU}}{r_{DU}} = k\left(\frac{Q_{TC}}{r_{TC}} + \frac{Q_{BC}}{r_{BC}} + \frac{Q_{SU}}{r_{SU}} + \frac{Q_{DU}}{r_{DU}}\right)$

$$V_{total} = (9 \times 10^9\ \text{N}\bullet\text{m}^2/\text{C}^2)\left[\frac{30C}{3000m} + \frac{(-30C)}{2000m} + \frac{30C}{2000m} + \frac{(-30C)}{3000m}\right]$$

$$\boxed{V_{total} = 0\ \text{V}}$$

ii. $V_{total} = k\frac{Q_{TC}}{r_{TC}} + k\frac{Q_{BC}}{r_{BC}} + k\frac{Q_{SU}}{r_{SU}} + k\frac{Q_{DU}}{r_{DU}} = k\left(\frac{Q_{TC}}{r_{TC}} + \frac{Q_{BC}}{r_{BC}} + \frac{Q_{SU}}{r_{SU}} + \frac{Q_{DU}}{r_{DU}}\right)$

$$V_{total} = (9 \times 10^9\ \text{N}\bullet\text{m}^2/\text{C}^2)\left[\frac{30C}{3162m} + \frac{(-30C)}{2236m} + \frac{30C}{2236m} + \frac{(-30C)}{3162m}\right]$$

$$\boxed{V_{total} = 0\ \text{V}}$$

(d) $V_{total} = k\frac{Q_{TC}}{r_{TC}} + k\frac{Q_{BC}}{r_{BC}} + k\frac{Q_{SU}}{r_{SU}} + k\frac{Q_{DU}}{r_{DU}} = k\left(\frac{Q_{TC}}{r_{TC}} + \frac{Q_{BC}}{r_{BC}} + \frac{Q_{SU}}{r_{SU}} + \frac{Q_{DU}}{r_{DU}}\right)$

$$V_{total} = (9 \times 10^9\ \text{N}\bullet\text{m}^2/\text{C}^2)\left[\frac{30C}{2000m} + \frac{(-30C)}{1000m} + \frac{30C}{3000m} + \frac{(-30C)}{4000m}\right]$$

$$\boxed{V_{total} = -1.125 \times 10^8\ \text{V}}$$

(e) $PE_{total} = q_{TC}(V_{BC} + V_{SU} + V_{DU}) + q_{BC}(V_{TC} + V_{SU} + V_{DU}) + q_{SU}(V_{TC} + V_{BC} + V_{DU}) + q_{DU}(V_{TC} + V_{BC} + V_{SU})$

$$= \left(9x10^9\ \frac{N \bullet m^2}{C^2}\right)(30C)\left(\frac{-30C}{1000m} + \frac{30C}{5000m} + \frac{-30C}{6000m}\right) + \left(9x10^9\ \frac{N \bullet m^2}{C^2}\right)(-30C)\left(\frac{30C}{1000m} + \frac{30C}{5000m} + \frac{-30C}{6000m}\right)$$

$$+ \left(9x10^9\ \frac{N \bullet m^2}{C^2}\right)(30C)\left(\frac{30C}{1000m} + \frac{-30C}{5000m} + \frac{-30C}{6000m}\right) + \left(9x10^9\ \frac{N \bullet m^2}{C^2}\right)(-30C)\left(\frac{30C}{1000m} + \frac{-30C}{5000m} + \frac{30C}{6000m}\right)$$

$PE_{total} = -7.83 \times 10^9\ \text{J} - 8.5 \times 10^9\ \text{J} - 8.5 \times 10^9\ \text{J} - 7.3 \times 10^9\ \text{J} = \boxed{-3.27 \times 10^{10}\ \text{J} = PE_{total}}$

2. (a) Using the equation $V = \varepsilon e^{-\frac{t}{RC}}$ with t = RC (the time constant, τ) gives $V = \varepsilon e^{-1}$ = 0.368(10 V) = 3.68 V. Read the time from the graph when the voltage is 3.68 V. This time, 60 minutes (3600 s), is the time constant, τ = RC. So, 3600 s = R(8.0×10^{-6} F)

$R = 4.5 \times 10^{8}\ \Omega$

(b) $C = K\varepsilon_0 \frac{A}{d}$

$8.0 \times 10^{-6}\ \text{F} = (5.6)(8.85 \times 10^{-12}\ \text{C}^2/\text{N}\bullet\text{m}^2)\frac{A}{1.0x10^{-4}\,m}$

$A = 16\ \text{m}^2$

(c) $R = \rho \frac{L}{A}$

$4.5 \times 10^{8}\ \Omega = \rho \frac{1.0x10^{-4}\,m}{16m^2}$

$\rho = 7.2 \times 10^{13}\ \Omega\bullet\text{m}$

(d) $Q = Q_0 e^{-\frac{t}{RC}} = C\varepsilon e^{-\frac{t}{RC}} = (8.0 \times 10^{-6}\ \text{F})(10\ \text{V})e^{-\frac{6000S}{(4.5x10^{8}\,\Omega)(8.0x10^{-6}\,F)}}$

$Q = 1.5 \times 10^{-5}\ \text{C}$

3. (a) $I = \frac{\varepsilon}{R}$ The direction would be to the left (conventional current).

(b) The direction of the current in the cable must be to the right. The force between two parallel wires is away from one another when the currents are in opposite directions. [Further explanation: For the force to be upward on the rod, the magnetic field generated by the current in the conducting cable must be out of the page according to the second right-hand rule (put your fingers in the direction of the current in the rod, rotate your wrist until your fingers can curl in the direction of the magnetic field and your thumb will be pointing in the direction of the force on the current-carrying rod in the presence of the magnetic field). For the magnetic field created by thecurrent in the conducting cable to be out of the page in the vicinity of the rod, the current in the cunducting cable must be to the right according to the first right-hand rule(put your thumb in the direction of the current and the circular direction in which your fingers can curl show the direction of the magnetic field created by the current-carrying conducting cable).]

(c) $\Sigma F = F_c - F_g$

$$\frac{\mu_0}{2\pi}\frac{I_R I_C}{r} l - mg = 0 \qquad \left[\mu_o = 4\pi x 10^{-7}\frac{T \cdot m}{A}\right]$$

$$I_c = \frac{mgr}{\left(2x10^{-7}\right) I_R l}$$

(d) $$\phi = B \bullet A = \int_r^{r+d} \frac{\mu_o}{2\pi}\frac{I}{R} l dR = \frac{\mu_o}{2\pi} I \cdot l \int_r^{r+d} \frac{dR}{R} = \frac{\mu_o}{2\pi} I \cdot l \ln R\Big]_r^{r+d} = \frac{\mu_o}{2\pi} I \cdot l\left[\ln(r+d) - \ln R\right]$$

$$\phi = \frac{\mu_o}{2\pi} I \cdot l \ln\left(\frac{r+d}{r}\right)$$