1. (a)

____ increases ____ decreases __**x**__ remains the same

The force of gravity is a constant throughout the path and is always in the downward direction. The force of air resistance, F, depends on the speed. The magnitude of the air resistance force is directly proportional to the speed of the ball and in the opposite direction of the velocity. As the ball moves upward its speed decreases, so, the magnitude of F is decreasing and its direction is downward. The net force is the vector sum of these two downward forces (gravity and air resistance) and this net force equals Ma according to Newton's Second Law of Motion. Since F is decreasing as the ball moves upward, the net force decreases, thus, the acceleration decreases

(b) $-Mg - kv = Ma$

$$\boxed{-g - \frac{k}{M}v = \frac{dv}{dt}}$$

(c) $-Mg + kv = Ma = 0$

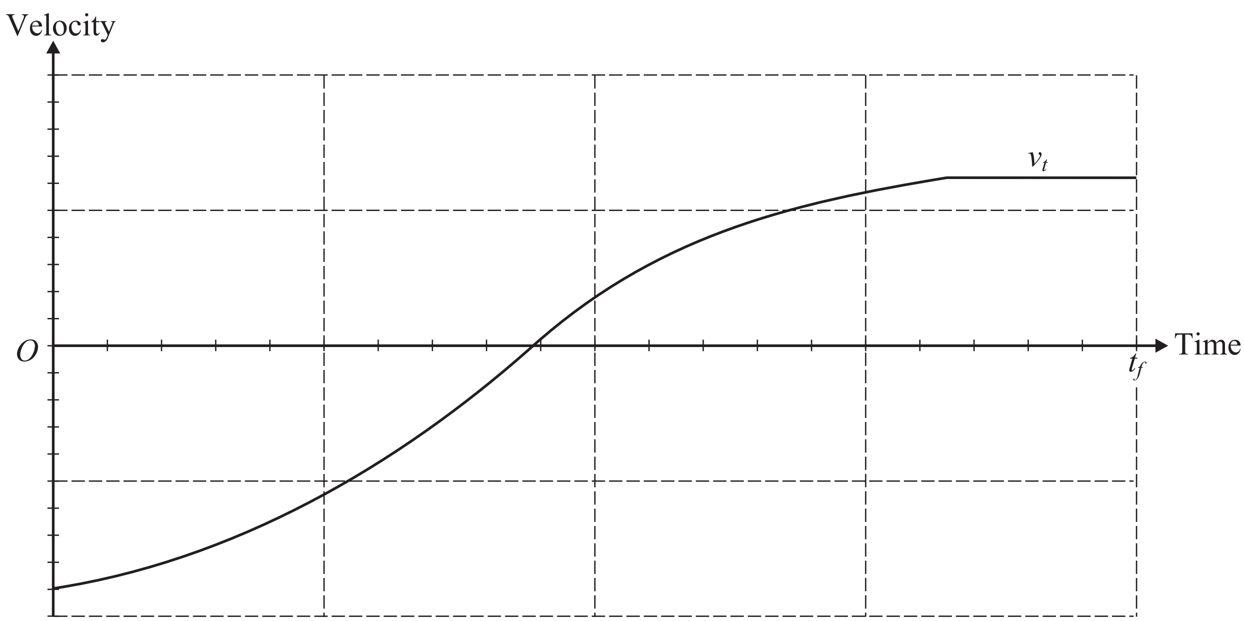
$$\boxed{v = \frac{M}{k}g}$$

(d)

____longer to rise __**x**__longer to fall

The acceleration is greater on the way up because the forces due to gravity and air resistance are in the same direction, thus, making a greater net force on the ball than on the way down where these two forces act in opposite directions. The distance it rises is the same distance it falls. Therefore, it will take longer to fall due to its smaller acceleration than it did to rise. Furthermore, its average velocity will greater on the way up than on the way down due to this difference in the accelerations.

(e)



Where v_t is the terminal velocity of the ball if it reaches this value which depends v_0.

2. (a) $\boxed{F = G\frac{M_S m_m}{r^2}}$

(b) $G\frac{M_S m_m}{r^2} = m_m\frac{v^2}{r}$, where $v = \frac{2\pi r}{T}$

$$G\frac{M_S}{r} = \left(\frac{2\pi r}{T}\right)^2$$

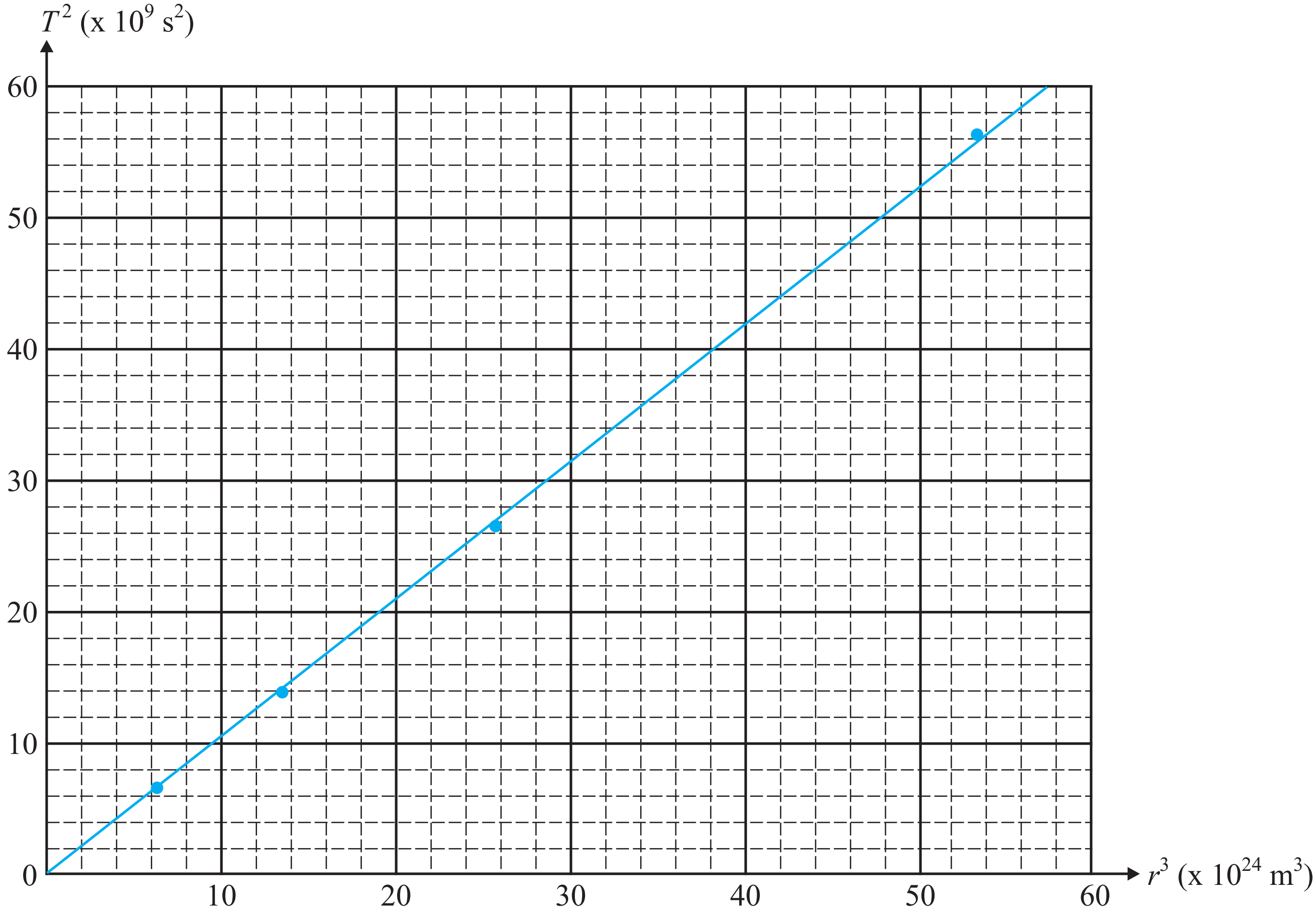
$$\boxed{T = \sqrt{\frac{4\pi^2}{GM_S}}\,r^{3/2}}$$

(c) T^2 vs. r^3 or r^3 vs. T^2

(d)

Orbital Period, T (seconds)	Orbital Radius, R (meters)	(Orbital Period)^2, T^2 [(seconds)^2]	(Orbital Radius)^3, R^3 [(meters)^3]
8.14×10^4	1.85×10^8	6.63×10^9	6.33×10^{24}
1.18×10^5	2.38×10^8	1.39×10^{10}	1.35×10^{25}
1.63×10^5	2.95×10^8	2.66×10^{10}	2.57×10^{25}
2.37×10^5	3.77×10^8	5.62×10^{10}	5.35×10^{25}

(e)



(f) $m = \frac{\Delta y}{\Delta x} = \frac{\Delta T^2}{\Delta r^3} = \frac{50 \times 10^9 s^2 - 2 \times 10^9 s^2}{48 \times 10^{24} m^3 - 2 \times 10^{24} m^3} = 1.0 \times 10^{-15}\, s^2/m^3 = \frac{4\pi^2}{GM_s}$, so $\boxed{M_s = 5.92 \times 10^{26}\, kg}$

3. (a) $L = I\omega$

$$\boxed{L = \frac{1}{3}M_1 d^2\omega}$$

(b) $L_1 + L_2 = L_1' + L_2'$

$I\omega + 0 = 0 + I_2\omega_2$

$\frac{1}{3}M_1 d^2\omega = M_2 d^2 \frac{v}{d}$

$$\boxed{v = \frac{1}{3}\frac{M_1}{M_2}d\omega}$$

(c) $KE = KE'$

$TKE + RKE = TKE' + RKE''$

$0 + \frac{1}{2}I\omega^2 = \frac{1}{2}mv^2 + 0$

$\frac{1}{2}\left(\frac{1}{3}M_1 d^2\right)\omega^2 = \frac{1}{2}M_2\left(\frac{1}{3}\frac{M_1}{M_2}d\omega\right)^2$

$$\boxed{\frac{M_1}{M_2} = 3}$$

<u>OR</u>

since $v = r\omega$

$\frac{1}{3}\frac{M_1}{M_2}d\omega = d\omega$

$\frac{1}{3}\frac{M_1}{M_2} = 1$

$\frac{M_1}{M_2} = 3$

(d) $L_1 + L_2 = L_1' + L_2'$

$I\omega + 0 = 0 + I_2\omega_2$

$\frac{1}{3}M_1 d^2\omega = M_1 x^2 \frac{v}{x}$

$v = \frac{1}{3}\frac{d^2}{x}\omega$

$KE = KE'$

$TKE + RKE = TKE' + RKE''$

$0 + \frac{1}{2}I\omega^2 = \frac{1}{2}mv^2 + 0$

$\frac{1}{2}\left(\frac{1}{3}M_1 d^2\right)\omega^2 = \frac{1}{2}M_1\left(\frac{1}{3}\frac{d^2}{x}\omega\right)^2$

$1 = \frac{1}{3}\frac{d^2}{x^2}$

$x^2 = \frac{1}{3}d^2$

$$\boxed{x = \sqrt{\frac{1}{3}}d}$$

1. (a) i. The magnitude of the electric field is greatest at point C because that is where the electric field lines are the most tightly spaced.

ii. The electric potential is greatest at point A. Electric potential is related to electric field by $V = -\int \vec{E} \cdot d\vec{l}$. Applying this relation to this field diagram shows the position of point A is at the greatest potential. In other words, it is furthest from the apparent source of these field lines. The source appears to be a negative charge to the right of the diagram.

(b) i. The electron will move to the left with an increasing speed and a decreasing acceleration.

ii. $qV = \frac{1}{2}mv^2$

$$\left(1.6 \text{ x } 10^{-19}\text{C}\right)\left(10 \text{ V}\right) = \tfrac{1}{2}\left(9.11 \text{ x } 10^{-31}\text{ kg}\right)v^2$$

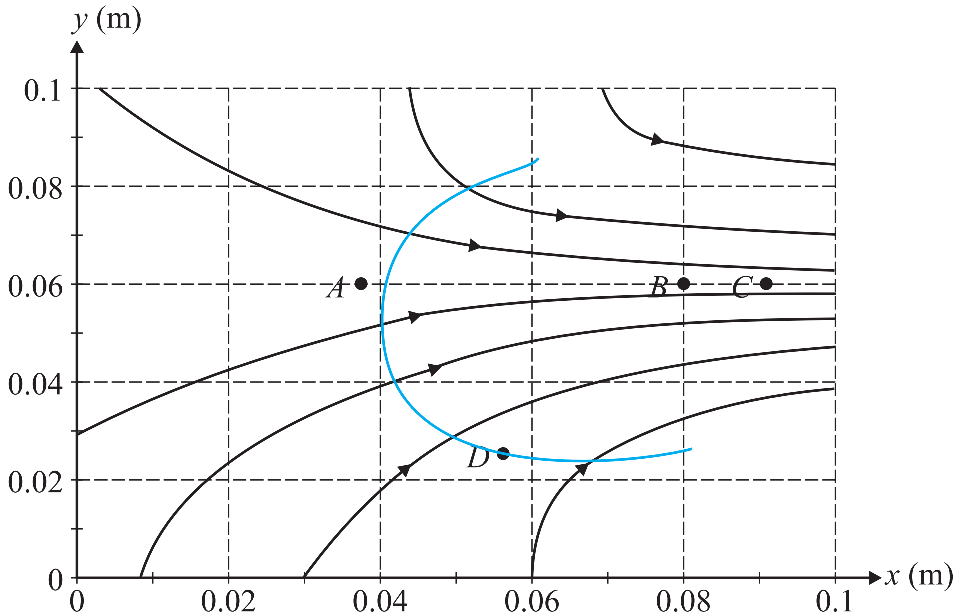
$$\boxed{v = 1.87 \text{ x } 10^{6}\text{ m/s}}$$

(c) Assuming the electric field is essentially constant over this short distance, $V = -\int \vec{E} \cdot d\vec{l} = -\vec{E}\int d\vec{l}$

$$20 \text{ V} = E\left(0.01 \text{ m}\right)$$

$$\boxed{E = 2000 \text{ V/m}}$$

(d)



2 (a) Immediately after the switch is closed, the inductor has a very large impedance (like an infinite resistance) resulting in, essentially, no current flow in that branch (it is as if the branch is open), so, the rest of the circuit is two resistors in series.

$$I_0 = \frac{\varepsilon}{R_T}$$

$$\boxed{I_0 = \frac{\varepsilon}{R_1 + R_2}}$$

(b) $V_L = LdI/dt = IR_2$

$$dI/dt = \frac{1}{L}\frac{\varepsilon}{(R_1 + R_2)}R_2$$

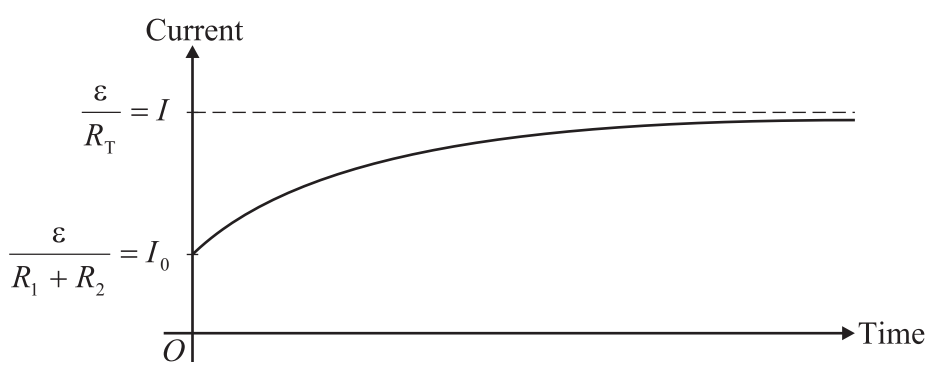
$$\boxed{dI/dt = \frac{\varepsilon R_2}{L(R_1 + R_2)}}$$

(c) A long time after the switch has been closed, there is essentially no impedance in the inductor since it opposes changes in current and the current will be essentially constant. Therefore, almost all the current passing through R_1 will flow through that branch (it is as if the branch is shorted out) and almost no current will flow through resistor, R_2.

$$I = \frac{\varepsilon}{R_T}$$

$$\boxed{I = \frac{\varepsilon}{R_1}}$$

(d)



(e) $V_2 = I_0 R_2 = \left(\frac{\varepsilon}{R_1}\right)R_2$

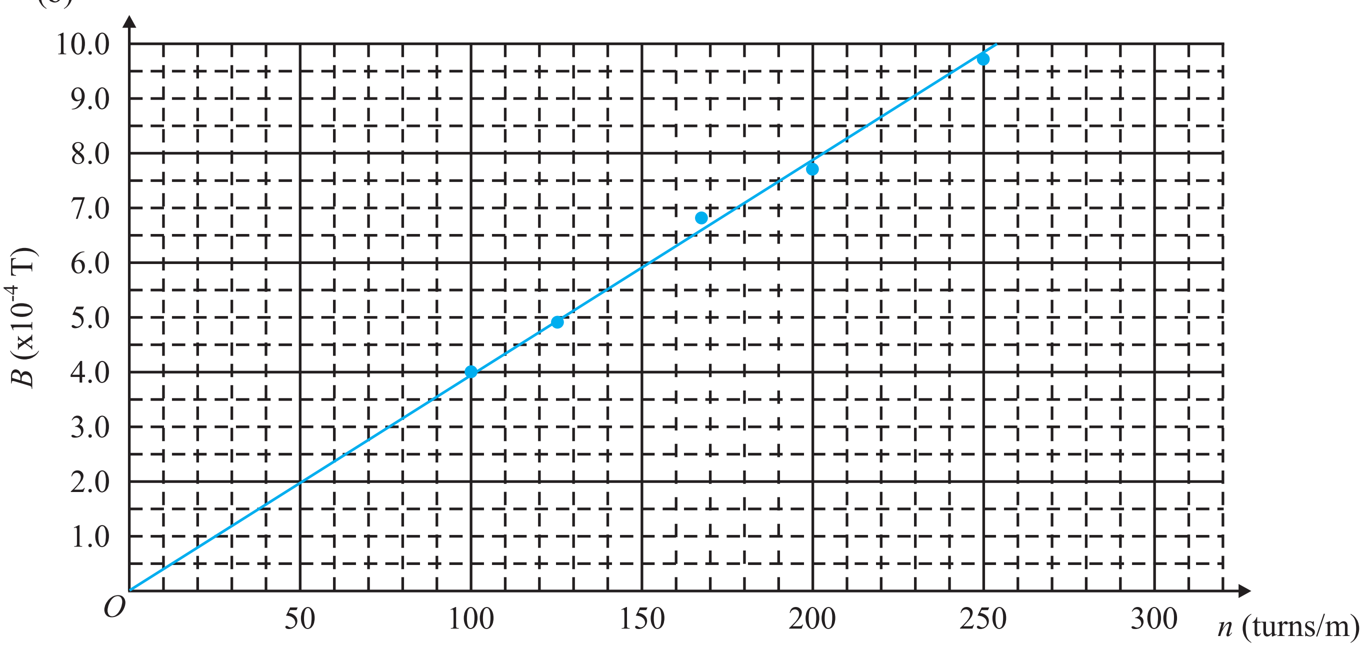
$$\boxed{V_2 = \varepsilon\left(\frac{R_2}{R_1}\right)}$$

3. (a)

Trial	Position of End Q (cm)	Measured Magnetic Field (T) (directed from P to Q)	n (turns/m)
1	40	9.70×10^{-4}	250
2	50	7.70×10^{-4}	200
3	60	6.80×10^{-4}	167
4	80	4.90×10^{-4}	125
5	100	4.00×10^{-4}	100

Sample Calculation for Trial 1: $n = \dfrac{N}{l} = \dfrac{100 \text{ turns}}{0.40 \text{ m}} = 250 \text{ turns / m}$

(b)



(c) $B = \mu_0 nI$, so, $\mu_0 = \dfrac{B}{nI}$. The current is a constant 3.0 A/turn in this experiment. Therefor, the slope divided by 3.0 A/turn will give μ_0.

Slope, $m = \dfrac{\Delta B}{\Delta n} = \dfrac{(10.0 - 2.0) \text{ x } 10^{-4} \text{ T}}{(254 - 50) \text{ turns / m}} = 3.92 \text{ x } 10^{-6} \text{ T} \cdot \text{turns / m}$

$$\mu_0 = \frac{m}{I} = \frac{3.92 \text{ x } 10^{-6} \text{ T} \cdot \text{turns / m}}{3.0 \text{ A / turn}} = \boxed{1.31 \text{ x } 10^{-6} \ (\text{T} \cdot \text{m}) / \text{A} = \mu_0}$$

(d) $$\% \, error = \frac{|Experimental - Actual|}{Actual} \text{ x } 100\% = \frac{\left|\left[\left(1.31 \text{ x } 10^{-6} - 4\pi \text{ x } 10^{-7}\right)(\text{T} \cdot \text{m}) / \text{A}\right]\right|}{4\pi \text{ x } 10^{-7} \ (\text{T} \cdot \text{m}) / \text{A}} = \boxed{0.425\%}$$