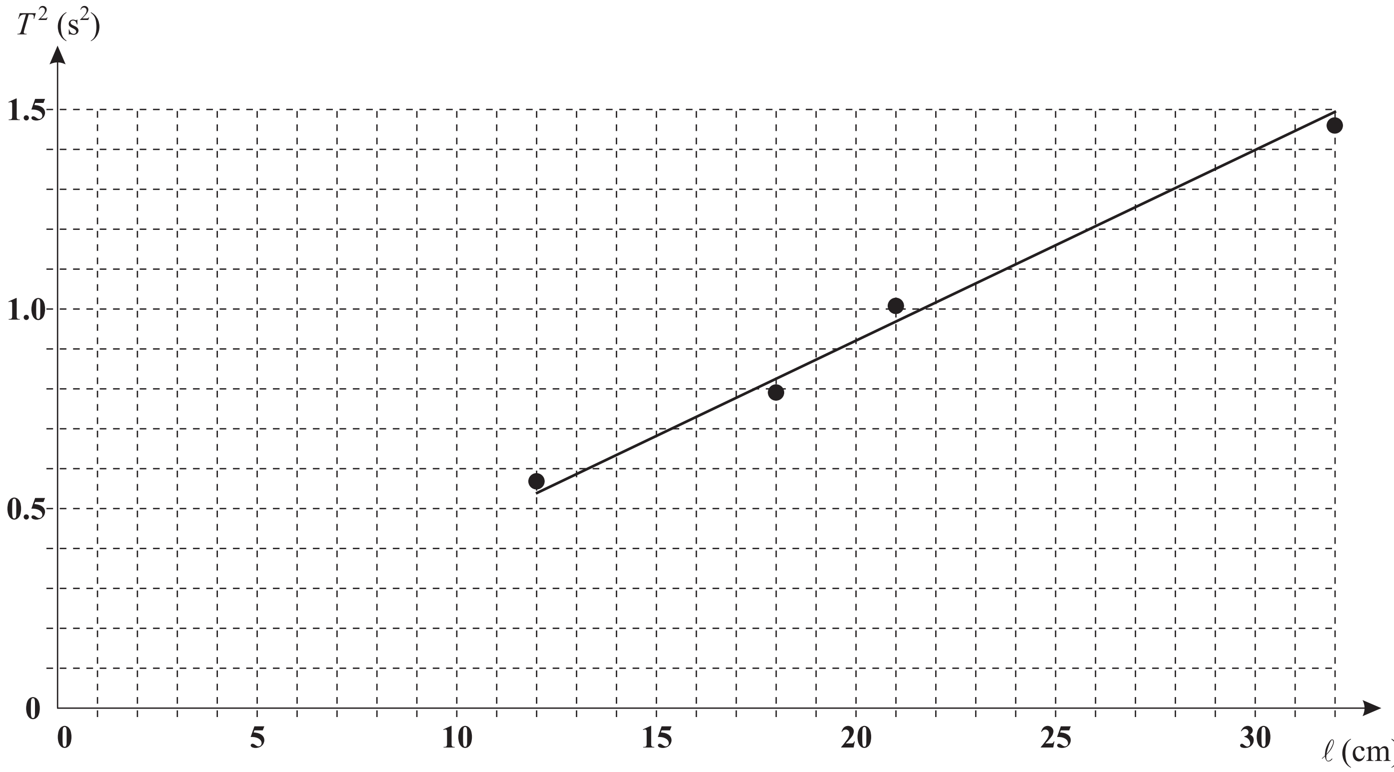
1. (a)

ℓ (cm)	t_{10} (s)	T (s)	T^2 (s^2)
12	7.62	**0.762**	**0.581**
18	8.89	**0.889**	**0.790**
21	10.09	**1.009**	**1.018**
32	12.08	**1.208**	**1.459**

(b)



(c) Since the equation of this straight line is $T^2 = m\ell$ (where m is the slope of the line) and the equation for the period of a pendulum ($T = 2\pi\sqrt{\frac{\ell}{g}}$) can be rearranged to $T^2 = \frac{4\pi^2}{g}\ell$, then the slope must equal $\frac{4\pi^2}{g}$. The slope of T^2 vs. ℓ is $m = \frac{1.5s^2 - 0.55s^2}{0.32m - 0.12m}$ = 4.52 s^2/m. Therefore, 4.52 s^2/m $= \frac{4\pi^2}{g}$, so $g_{exp} = \frac{4\pi^2}{4.52 s^2/m}$ = 8.73 m/s^2.

g_{exp} = 8.73 m/s^2

(d) No. If ±4% is applied to the experimental value of 8.73 m/s^2 (8.73 x 0.04 = 0.35), the result is 8.38 m/s^2 to 9.08 m/s^2. The accepted value of 9.80 m/s^2 does not fall within this range, therfore, the experimental value is not in agreement with the value 9.80 m/s^2.

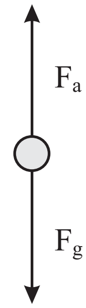
(e) $\Sigma F = F_{exp} - F_g = ma$

$mg_{exp} - mg = ma$

$a = g_{exp} - g$ = 8.73 m/s^2 -9.80 m/s^2

a = - 1.07 m/s^2 downward

2. (a)



(b) The magnitude of the acceleration of the ball decreases as the ball approaches terminal speed. There are two forces acting on the ball as it falls: the downward force of gravity which is a constant and the upward force of air drag that increases as the speed of the ball increases. The magnitude of the acceleration depends on the net force which is the sum of these two forces. Before the ball reaches the terminal speed the downward force of gravity is greater than the upward force of air drag, so, the net force will be downward and the acceleration will be downward. Since there is an acceleration (downward), the speed will be increasing. Remember, the magnitude of the upward force of air drag depends on the speed. Since the speed is increasing before the ball reaches terminal speed, the magnitude of the upward force of air drag is increasing. Therefore, the net force will be decreasing and, hence, the magnitude of the ball's acceleration will be decreasing before the ball reaches its terminal speed.

(c) $\sum F = F_a - F_g = ma$

$$bv^2 - mg = m\frac{dv}{dt}$$

$$\frac{dv}{bv^2 - mg} = \frac{dt}{m}$$

(d) $\sum F = F_a - F_g = ma$

$$bv_t^2 - mg = 0$$

$$bv_t^2 = mg$$

$$v_t^2 = \frac{mg}{b}$$

$$\boxed{v_t = \sqrt{\frac{mg}{b}}}$$

(e) $E_{before} = E_{final}$

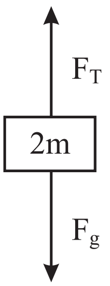
$$GPE = KE + TE$$

$$mgh = \tfrac{1}{2}mv_t^2 + E_a$$

$$Ea = mgh - \tfrac{1}{2}mv_t^2 = mgh - \tfrac{1}{2}m\left(\sqrt{\frac{mg}{b}}\right)^2$$

$$\boxed{Ea = mgh - \tfrac{1}{2}\frac{m^2 g}{b}}$$

3. (a)

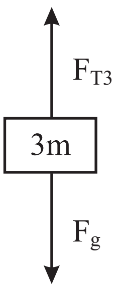


$\Sigma F = F_T - F_g = ma$

$F_T - 2mg = 0$

$\boxed{F_T = 2mg}$

(b)

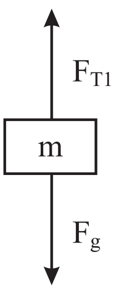


i. $\Sigma F = F_{T3} - F_g = ma$

$F_{T3} - 3mg = -3m\frac{g}{3}$

$F_{T3} = -mg + 3mg$

$\boxed{F_{T3} = 2mg}$



ii. $\Sigma F = F_{T1} - F_g = ma$

$F_{T1} - mg = \frac{mg}{3}$

$F_{T1} = \frac{mg}{3} + mg = \frac{mg}{3} + \frac{3mg}{3}$

$\boxed{F_{T1} = \frac{4}{3}mg}$

iii. $\Sigma T = T_3 - T_1 = I\alpha$ ($a_T = R_1\alpha$ so $\alpha = \frac{a_T}{R_1}$

$R_1F_{T3} - R_1F_{T1} = I_1\frac{a_T}{R_1}$ (Divide both sides by R_1)

$F_{T3} - F_{T1} = I_1a_T$

$2mg - \frac{4}{3}mg = I_1\frac{g}{3R_1^2}$ (Multiply both sides by 3 and divide by g)

$(6m - 4m)R_1^2 = I_1$

$\boxed{I_1 = 2mR_1^2}$

(c) i. The linear speed of a point on the edge of original pulley equals the linear speed of a point on the edge of second pulley and the linear speed of the cord. So,

$R_1\omega_1 = R_2\omega_2$

$\omega_2 = \frac{R_1}{R_2}\omega_1 = \frac{R_1}{2R_1}\omega_1$

$\boxed{\omega_2 = \frac{1}{2}\omega_1}$

ii. $L_2 = I_2\omega_2 = 16I_1\frac{1}{2}\omega_1$

$\boxed{L_2 = 8I_1\omega_1}$

iii. $KE = \frac{1}{2}I_1\omega_1^2 + \frac{1}{2}I_2\omega_2^2$

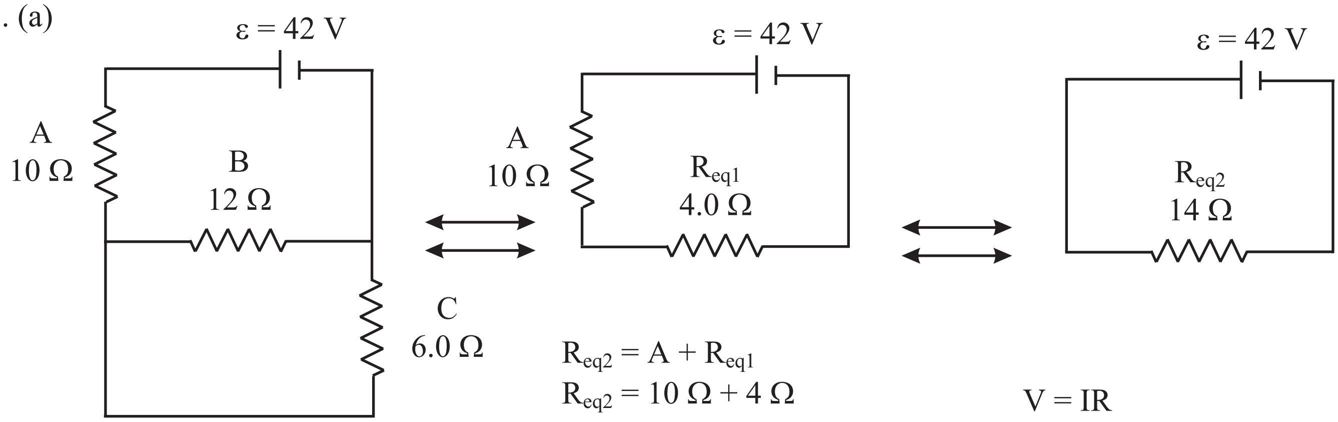
$KE = \frac{1}{2}I_1\omega_1^2 + \frac{1}{2}(16)I_1(\frac{1}{2}\omega_1)^2$

$KE = \frac{1}{2}I_1\omega_1^2 + \frac{1}{2}(16)I_1\frac{1}{4}\omega_1^2$

$KE = \frac{1}{2}I_1\omega_1^2 + 2I_1\omega_1^2$

$\boxed{KE = 2\frac{1}{2}I_1\omega_1^2}$

1. (a)



$$\frac{1}{R_{eq1}} = \frac{1}{B} + \frac{1}{C}$$
$$\frac{1}{R_{eq1}} = \frac{1}{12} + \frac{1}{6}$$
$$R_{eq1} = 4.0\ \Omega$$

$V = IR$
$V_{eq1} = I_B R_B$
$12\ V = I_B(12\ \Omega)$
$I_B = 1\ A$

$P_B = I_B^2 R_B = (1\ A)^2(12\ \Omega)$

$\boxed{P_B = 12\ W}$

$R_{eq2} = A + R_{eq1}$
$R_{eq2} = 10\ \Omega + 4\ \Omega$
$R_{eq2} = 14\ \Omega$

$V = IR$
$V_{eq1} = I_A R_{eq1}$
$V_{eq1} = (3\ A)(4\ \Omega)$
$V_{eq1} = 12\ V$

$V = IR$
$V_{eq1} = I_C R_C$
$12\ V = I_C(6\ \Omega)$
$I_C = 2\ A$

$P_C = I_C^2 R_C = (2\ A)^2(6\ \Omega)$

$\boxed{P_C = 24\ W}$

$V = IR$
$\varepsilon = I_A R_{eq2}$
$42\ V = I_A(14\ \Omega)$
$I_A = 3\ A$

$P_B = I_B^2 R_B$
$P_B = (3\ A)^2(10\ \Omega)$

$\boxed{P_A = 90\ W}$

$P_A > P_C > P_B$, so lightbulb A will be brighter than C which is brighter than B.

(b) i. The inductor creates a counter ε that is equal to the ε from the battery so no current flows through lightbulb C ($I_C = 0$ A). Therfore, it is as if the circuit branch with lightbulb C is not there, so lightbulbs A and B are in series and the current through lightbulbs A (I_A) and B (I_B) is the same (common). The total resistance (R_T) in the circuit is the sum of the resistances in lightbulbs A and B (10 Ω + 12 Ω) wich is 22 Ω.

$$I_A = I_B = \frac{\varepsilon}{R_T} = \frac{42V}{22\Omega} = 1.9\ A$$

$P_A = I_A^2 R_A = (1.9\ A)^2(10\ \Omega)$ $\quad$ $P_B = I_B^2 R_B = (1.9\ A)^2(12\ \Omega)$ $\quad$ $P_C = I_C^2 R_C = (0\ A)^2(6\ \Omega)$

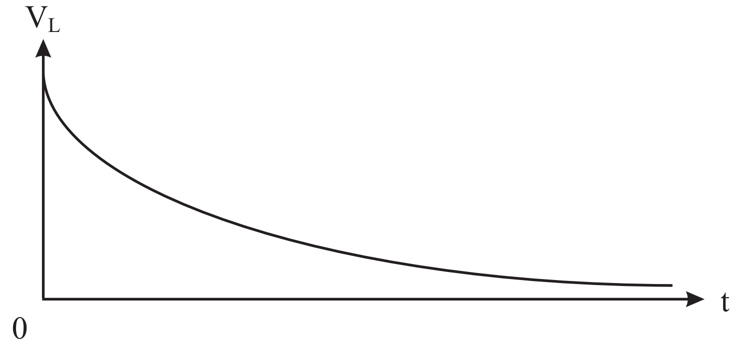
$\boxed{P_A = 36\ W}$ $\quad$ $\boxed{P_B = 43\ W}$ $\quad$ $\boxed{P_C = 0\ W}$

$P_B > P_A > P_C$, so lightbulb B will be brighter than A which is brighter than C.

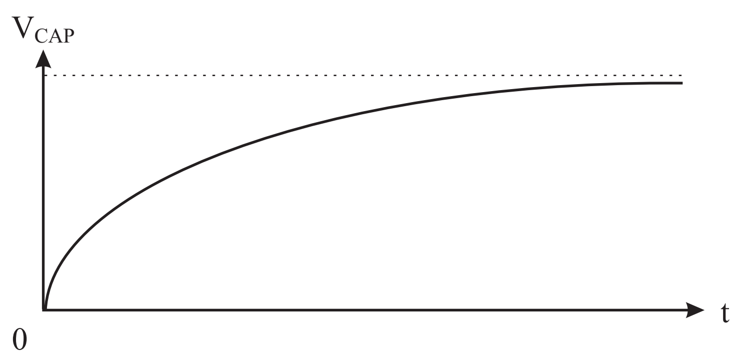
ii. A long time after the switch is closed the current is constant so the inductor has no effect on the circuit so it behaves as in part (a.). That is, $P_B > P_A > P_C$, so lightbulb B will be brighter than A which is brighter than C.

1. (continued)

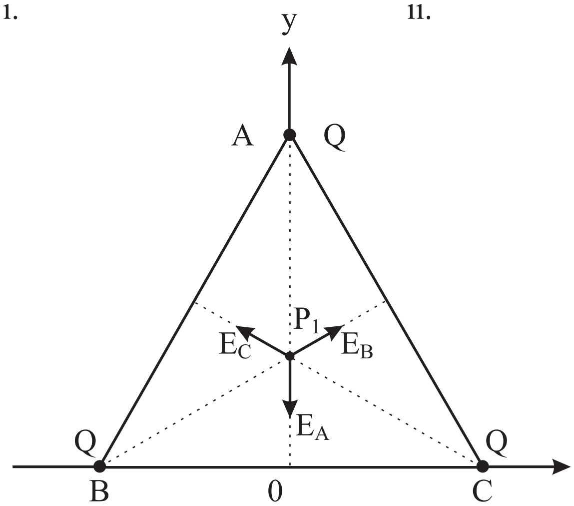
(c)



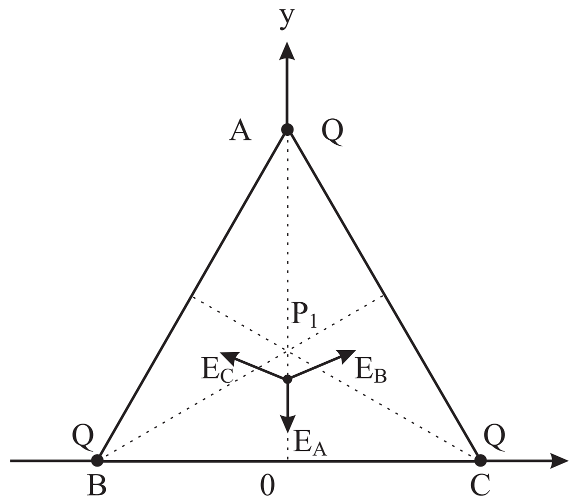
(d)



2. (a) i.



ii.



ii. (continued)

	Greater than at P_1	Less than at P_1	The same as at P_1
E_A		**X**	
E_B	**X**		
E_C	**X**		

(b) The y-axis is equidistant from points B and C which are both on the x-axis. Therefore, the angle between the x-axis and a line joining point B to any point on the y-axis will be equal to the angle between the x-axis and a line joining point C to that same point on the y-axis. Due to this symmetric geometry , the magnitude of the x-components of the electric fields of charges B and C will always be equal in magnitude and opposite in direction and,thus, will add to zero. The electric field from charge C has an x-component of zero.

(c) $V = V_A + V_B + V_C = \dfrac{kQ}{\dfrac{\sqrt{3}l}{2} - y} + \dfrac{kQ}{\sqrt{\dfrac{1}{2}l^2 + y^2}} + \dfrac{kQ}{\sqrt{\dfrac{1}{2}l^2 + y^2}}$

$$\boxed{V = kQ\left(\frac{1}{\frac{\sqrt{3}l}{2} - y} + \frac{2}{\sqrt{\frac{1}{2}l^2 + y^2}}\right)}$$

(d) Take the derivative of the potential with respect to y and set this equal to zero and solve for y because $E = -\dfrac{dV}{dy}$ and the electric field should be zero at these points.

3. (a) i. $\oint E \bullet dA = \frac{Q}{\kappa\varepsilon_0}$ let $\sigma = \frac{Q}{A} = \frac{dQ}{dA}$

$E\oint dA = \frac{Q}{\kappa\varepsilon_0}$

$E2\pi rL = \frac{Q}{\kappa\varepsilon_0}$

$$\boxed{E = \frac{Q}{2\pi\kappa\varepsilon_0 L}\frac{1}{r}}$$

ii. Since there is a charge of +Q on the inner surface and a charge of -Q on the outer surface the net charge within the Gaussian surface (cylinder) that encompasses the entire capacitor is zero. Thus,

$$\boxed{E = 0}$$

(b) i. $V = -\int_a^b Edr = -\int_a^b \frac{Q}{2\pi\kappa\varepsilon_0 L}\frac{1}{r}dr = \frac{Q}{2\pi\kappa\varepsilon_0 L}\int_a^b \frac{dr}{r} = \frac{Q}{2\pi\kappa\varepsilon_0 L}[\ln(b) - \ln(a)]$

$$\boxed{V = \frac{Q}{2\pi\kappa\varepsilon_0 L}\ln\left(\frac{b}{a}\right)}$$

ii. $Q = CV$

$C = \frac{Q}{V} = \frac{Q}{\frac{Q}{2\pi\kappa\varepsilon_0 L}\ln\left(\frac{b}{a}\right)}$

$$\boxed{C = 2\pi\kappa\varepsilon_0 L\left[\ln\left(\frac{b}{a}\right)\right]}$$

(c) i. $\int Bdl = \mu_0 I$ Choose a circle for an Amperian path. $V = I_a R$, $I_a = \frac{\varepsilon}{R}$

$B\int dl = \mu_0 I_a$

$B2\pi r = \mu_0\frac{\varepsilon}{R}$

$$\boxed{B = \frac{\mu_0\varepsilon}{2\pi R}\frac{1}{r}}$$

ii. $\int Bdl = \mu_0 I$ $V = I_a R$, $I_a = \frac{\varepsilon}{R}$ $V = I_b R$, $I_b = \frac{3\varepsilon}{R}$

$B\int dl = \mu_0 I_T$

$B2\pi r = \mu_0\frac{4\varepsilon}{R}$

$$\boxed{B = \frac{2\mu_0\varepsilon}{\pi R}\frac{1}{r}}$$

$I_T = I_a + I_b$

$I_T = \frac{\varepsilon}{R} + \frac{3\varepsilon}{R}$

$I_T = \frac{4\varepsilon}{R}$