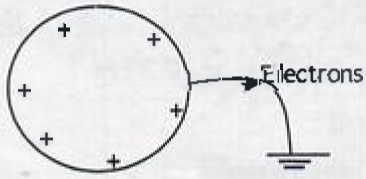
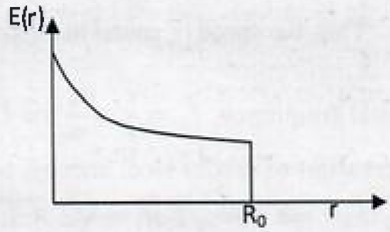
JUNE 2004

1.(i)

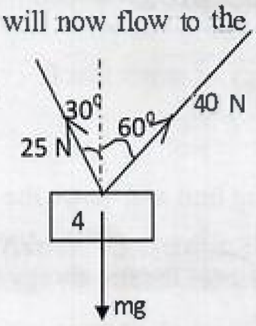


(ii)



N.B: When the negative charge is placed at the centre of the sphere, it induces positive charges on the walls of the sphere and negative charges on the outside. Since the sphere is earth, electrons on the surface will now flow to the earth, leaving the outside surface with a zero net charge.

2.



Resolving

Vertically, $40cos60° + 25cos30° - mg = ma_y$

$\Rightarrow 4a_y = 40 \times 0.5 + 25 \times 0.866 - 4 \times 9.8 = 2.45$

$\Rightarrow a_y = 0.613ms^{-2}$ --------- -(1)

Horizontally, $40sin60° - 25sin30° = ma_x \Rightarrow 4a_x = 22.14$

$\Rightarrow a_x = 5.535\ ms^{-2}$ ------------ -(2)

$\vec{a} = (5.535\hat{\imath} + 0.613\hat{\jmath})ms^{-2} \Rightarrow a = \sqrt{5.535^2 + 0.613^2} = 5.6ms^{-2}$

3.

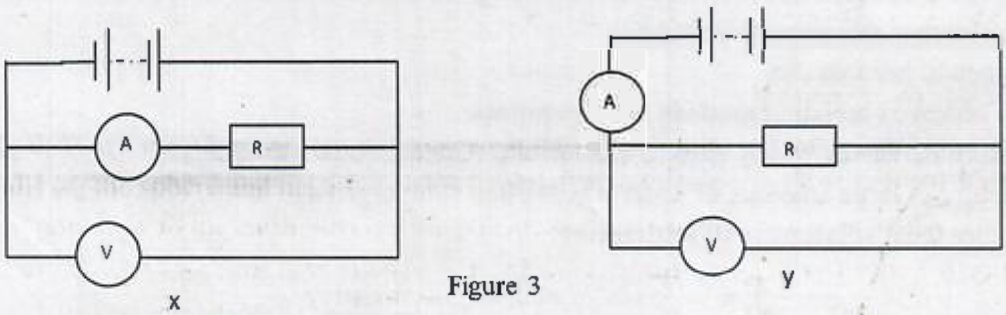


Figure 3

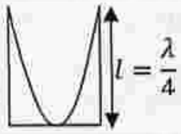
(i) It can be seen in figure 3 (x) that the voltmeter measures a voltage V but the actual voltage drop across the unknown resistance R is V_R, given by the expression V_R =IR, where I is the current through the resistance R. The indicated value of the voltage drop, V is given by= $IR + IR_a$, where, R_a is the internal resistance of the ammeter. The internal resistance of the ammeter is usually very small and so its p.d drop. If the resistance under measurement is large enough, then V_R will be much greater than V_a, hence keeping the error in the measurement very low.

This method is therefore recommended for the measurement of large values of resistances. This method in electrotechnics is called the upset connection.

(ii) In figure 3 (y), the voltmeter measures a voltage V which is the actual voltage drop across the across the unknown resistance R, since the voltmeter is in parallel with R alone. Note here that the ammeter reads a current I not the current through the unknown resistance R. if the resistance of R is much smaller than the resistance of the voltmeter, then the greater part of the current will flow through the unknown resistance R, hence reducing the error in the measurement of R.

This method is therefore acceptable when the value of the resistance is much smaller than the internal resistance of the voltmeter. In electrotechnics, this method is called the down set connection.

4.For a pipe closed at one end, the end is a node (See diagram below for the fundamental mode of vibration)



$v \propto \sqrt{T} \Rightarrow \frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}} \Rightarrow v_2 = v_1\sqrt{\frac{T_2}{T_1}} = 340\sqrt{\frac{279}{273.15}} = 354.53\ m/s$

Thus the speed of sound in air at 0°C is $354.53\ m/s$

The fundamental frequency, $f_0 = \frac{v}{\lambda} = \frac{v}{4l} \Rightarrow l = \frac{v}{4f_0} = \frac{354.53}{4\times512} = 0.173\ m = 17.3\ cm$

5.(i) By the conservation of mechanical energy, p.e lost= k.e gained

$i.e\ \ mgh = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{2gh} = \sqrt{2\times9.8\times1.5\times10^{-2}} = 0.54ms^{-1}$

(ii) By the work energy principle, k.e lost= work done against friction

$\Rightarrow \frac{1}{2}mv^2 = F.d \Rightarrow F = \frac{mv^2}{2d} = \frac{50\times10^{-3}\times(2\times9.8\times1.5\times10^{-2})}{2\times0.5} = 1.47\times10^{-2}N$

6. Reservoir → Dam → Penstock → Turbine → Generator → Transformer

- ✓ The **reservoir** stores the reserved water and provides the potential energy of water that is converted into kinetic energy of the turbine
- ✓ The dam backs up large quantity of water
- ✓ **The penstock** determines the amount of water admitted to the generating unit and hence the power output.
- ✓ The **turbine** converts the gravitational potential energy of water to rotational kinetic energy and provides the emf that produces electricity as it is linked to the generator
- ✓ The **generator** converts the rotational kinetic energy of the rotor blades to electrical energy
- ✓ The **transformer** steps up the voltage

(b) The environmental hazards are:

- ✓ The dam serves as breeding grounds for mosquitoes
- ✓ Dams can cause floods which leads to erosion and destruction of habitats
- ✓ The dam blocks large amounts of water which often submerge farm lands, ecosystems and may even require the displacement of settlements

7.(a) See June 2001 Q10

(b) $A = A_0e^{-\lambda t}$, with $\lambda = \frac{ln2}{t_{1/2}} = \frac{ln2}{5730}yr^{-1} \Rightarrow A = (3\times10^4)e^{-\left(\frac{ln2}{5730}yr^{-1}\right)(25000\ yr)} = 1.46\times 10^3$ Counts per minutes. This is the number of count per minutes in 2 kg.

Therefore the count rate in 0.3 kg will be $\frac{0.3}{2}\times1.46\times10^3 = 2.19\times10^2$ *counts per minute*

8. (a) Contact forces are those which come into play when bodies are in physical contact i.e when the bodies are touching each other. Examples include: friction, upthrust, etc. whereas action at a distances results when bodies are not in physical contact i.e not touching. Examples include: electrostatic force, gravitational force, magnetic force, etc.

(b) Consult your notebook

(c) Let the car driver take time t to catch up with the truck driver. At that instant, both of them must have travelled equal distances.

N.B: The time taken by the truck driver is (t+0.7)s

Distance travelled by car, $s_c = \frac{1}{2}at^2 = \frac{1}{2}\times 2t^2 = t^2$

Distance travelled by truck, $s_t = vt = \left(\frac{36\times1000}{60\times60}\right)(t + 0.7) = 10(t + 0.7)$

$s_c = s_t \Rightarrow t^2 = 10(t + 0.7) \Rightarrow t^2 - 10t - 7 = 0 \Rightarrow t = 5 \pm \sqrt{32} \Rightarrow t = 10.7\ sort = -0.7\ s$

But $t > o$. Thus the time taken by the car to catch up with the truck driver is 10.7 s.

(d) See June 2002 Q8

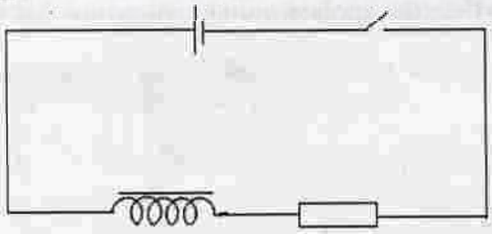
(e) Consult your notebook

(f) Amplitude, $a = \left(\frac{14-4}{2}\right) \times 10\ cm = 50\ cm$

Frequency, $f = \frac{1}{T} = \frac{1}{31days} = 0.032day^{-1}$

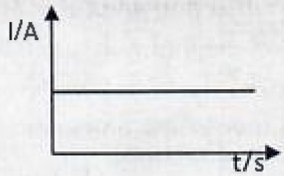
9.(a) (i) Self induction is the phenomenon whereby changing current in a coil and the resulting changing magnetic flux induces an emf in the same coil with the emf opposing the change producing it. That is the overall effect of self induced emf in a coil is acts against the voltage supply. While mutual induction is a phenomenon whereby the changing current in one coil (primary) induces an emf in another adjacent coil (secondary).

(ii)

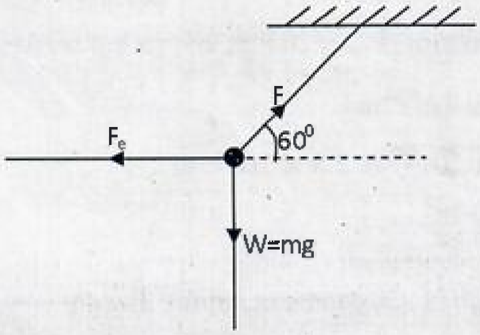


(iii) 29 min

(iv) If a resistor replaces the inductor, the current through inductor will be constant with time. Hence the graph will simple to a horizontal straight line (see diagram below)



(b)



F= tension force in the insulated thread

W=weight (i.e the gravitational pull of the earth on the charge)

F_e = electrostatic force

Since the charge is in equilibrium,

Resolving horizontally, $Fcos60° = F_e$ -------(1)

Resolving vertically, $Fsin60° = mg$ -------(2)

(1)/(2) $\Rightarrow tan60° = \frac{mg}{F_e} \Rightarrow F_e = \frac{mg}{tan60°}$ -----(3)

But $F_e = qE = \frac{qV}{d} \Rightarrow \frac{qV}{d} = \frac{mg}{tan60°} \Rightarrow q = \frac{dmg}{Vtan60°} = \frac{0.05\times0.05\times9.8}{600tan60°} = 3.36 \times 10^{-5}\ C$

(c)(i) See June 2001Q10

(ii) See your notebook for the setup

(iii) $V = -rI + E$. From the graph,

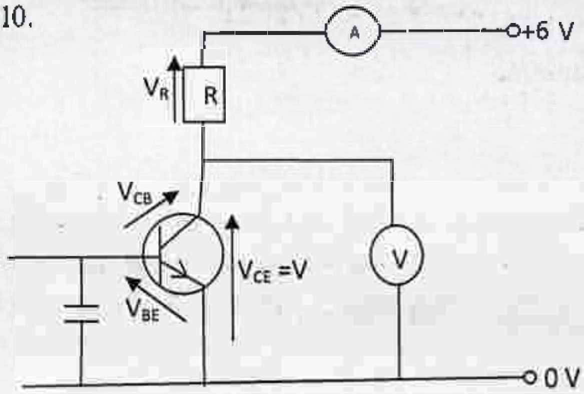
$E = 3.0\ V$ (b) internal resistance, r = negative slope of graph

$slope = \frac{3-0}{4} = -0.75\ \Omega \Rightarrow r = --0.75 = 0.75\Omega$

(d) $\rho = \frac{RA}{l} \Rightarrow l = \frac{RA}{\rho}, P = \frac{V^2}{R} \Rightarrow R = \frac{V^2}{P} \Rightarrow l = \frac{V^2 A}{P\rho} = \frac{20^2 \times 1.0\times10^{-7}}{10\times1.0\times10^{-6}} = 4.0m$

(e) Electrical energy consumed, $W = pt = 0.01kW \times 30 \times 24 = 7.2\ kW \Rightarrow cost = 7.2 \times 60 = 432\ frs$

10.



(a) (i) Applying KVL, $V_{BE} + V_{CB} + V_R - V_{CC} = 0$

Neglecting the voltage across the base – collector junction, $V_R = V_{CC} - V_{BE} = 6 - 0.6 = 5.4V$

$\Rightarrow I_C = \frac{V_R}{R} = \frac{5.4}{R}$. If the value of R is known then I_C can be found, which is the reading of the ammeter

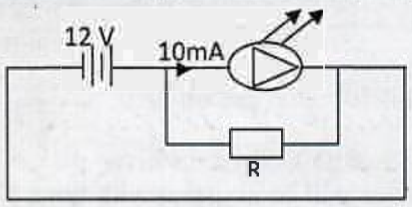
(ii) input voltage, $V_{in} = \frac{Q}{C} = \frac{3.2\,\mu C}{4.7\,\mu F} = 0.68V$

Voltage gain, $A = \frac{V_{out}}{V_{in}} = \frac{V_{CE}}{V_{in}} \Rightarrow V_{CE} = AV_{in} = 20 \times 0.68$

$\Rightarrow V_{CE} = 13.6V$. Thus the voltmeter reads 13.6 V

This value obtained the reading of the voltmeter is greater than the applied voltage, meaning that the transistor must have become saturated.

(b)



Forward bias resistance of LED, $R_f = \frac{12}{0.1} = 1200\Omega$

P.d across LED= P.d across R = 12 V

$\Rightarrow I_R R = 12 \Rightarrow R = \frac{12}{I_R} = \frac{12}{I - 0.01}$, where I is the current delivered by the battery

(c) (i) $Q = CV = 0.33 \times 10^{-6} \times 2.4 = 7.92 \times 10^{-7}C$

(ii) $W = \frac{1}{2}QV = \frac{1}{2} \times 7.92 \times 10^{-7} \times 2.4 = 9.50 \times 10^{-7}J$

(d)(i) The diode ensures that current flows only in one direction (forward bias direction).

(ii) $Q = C\Delta V = 0.33 \times 10^{-6} \times (4-1) = 4.62 \times 10^{-7}C$ (iii) $Q = I\Delta t \Rightarrow \Delta t = \frac{Q}{I} = \frac{4.62\times10^{-7}}{1.0\times10^{-6}} = 0.462\ s$

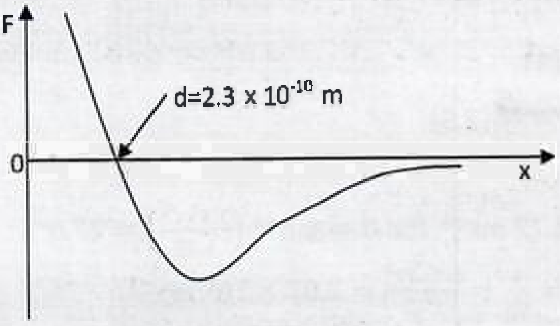
(e)(i) Molar volume= $\frac{molarmass}{density} = \frac{6.4\times10^{-2}}{8.9\times10^{3}} = 7.19 \times 10^{-6} m^3 mol^{-1}$

Atomic volume= $\frac{malorvolume}{N_a} = \frac{7.19\times10^{-6} m^3 mol^{-1}}{6.02\times10^{23} mol^{-1}} = 1.195 \times 10^{-29} m^3$

Assuming that atoms are cubes of sides, d, then $d = \sqrt[3]{1.195 \times 10^{-29}} = 2.3 \times 10^{-10}m$

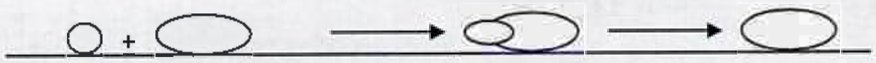
N.B: if we assume that the atoms are spherical, $V = \frac{4}{3}\pi\left(\frac{d}{2}\right)^3 = \frac{\pi d^3}{6}$

$$\Rightarrow d = \sqrt[3]{\frac{6 \times 1.195 \times 10^{-29}}{\pi}} = 2.8 \times 10^{-10}m$$



d is called the equilibrium position, where the net force is zero

(f) The pressure difference in the smaller droplet is greater than in the bigger one. Hence the smaller droplet breaks and enters the bigger one as shown in the diagram below. This is because surface tension is greater in small droplet than a big droplet.



(g) (i) See June 2006 Q8

(ii) The separation of molecules in a liquid is slightly greater than the equilibrium separation. Hence there is a net attractive force between each pair of neighboring molecules. The molecules in the bulk (or in the body) of the liquid experience a net zero force as each neighboring molecule is being pulled equally in all directions. The molecules at the surface of the liquid are without neighbors above and are more spaced out. Hence there is now a net force on each surface molecule, directed into the bulk of the liquid. Therefore the surface of a liquid is under a force due to attraction from its neighbors. So making molecules to resist being stretched or compressed from a widely spaced distance.

(iii) Molecules in the bulk of a liquid experience a net zero force as they are been pulled equally in all directions. While at the surface, molecules are without neighbors above and hence experience a net attractive force

(h) $h\rho\Delta h = 2\gamma\left(\frac{1}{r_2}-\frac{1}{r_1}\right) \Rightarrow \Delta h = \frac{2\gamma}{g\rho}\cdot\left(\frac{1}{r_2}-\frac{1}{r_1}\right) = \frac{2\times7.0\times10^{-2}}{9.8\times1000}\left(\frac{1}{10^{-3}}-\frac{1}{2\times10^{-3}}\right) = 0.007m = 7\ mm$