JUNE 2007

1.$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$.

From $F = \frac{Q^2}{4\pi\varepsilon_0 r^2} \Rightarrow \varepsilon_0 = \frac{Q^2}{4\pi F r^2} \Rightarrow [\varepsilon_0] = \frac{[Q]^2}{[F][r]^2} = \frac{A^2s^2}{kgms^{-2}m^2} = kg^{-1}m^{-3}A^2s^4$

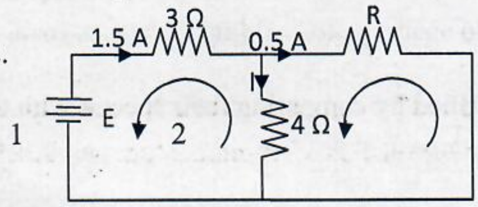
From $F = \frac{\mu_0 I^2 l}{2\pi r} \Rightarrow \mu_0 = \frac{2\pi rF}{I^2 l} \Rightarrow [\mu_0] = \frac{mkgms^2}{A^2m} = kgms^{-2}A^{-2}$

Units of LHS= units of $c = ms^{-1}$

Units of RHS = $\frac{1}{\sqrt{kgms^{-2}A^{-2}.kg^{-1}m^{-3}A^2s^4}} = \frac{1}{\sqrt{m^{-2}s^2}} = ms^{-1}$

Since the LHS and the RHS have the same base units, it means the equation is homogeneous.

2.



I = 1.5A – 0.5 A = 1.0 A

KVL in loop (1), $4(1) + 3(1.5) - E = 0$

$\Rightarrow E = 4 + 4.5 = 8.5$ A

KVL in loop (2), $4(1) - R(0.5) = 0 \Rightarrow R = 8.0\ \Omega$

3.Stress – strain is preferable because it gives the same shape for any length and area while the force – extension graphs for the same materials of different length and area have the same shape.

(ii) Work done = area of hysteresis loop OABCO

Area of one square = $1 \times 1000 \times 0.25 \times 10^{-3} = 0.25$ J

Approximate number of squares = 35

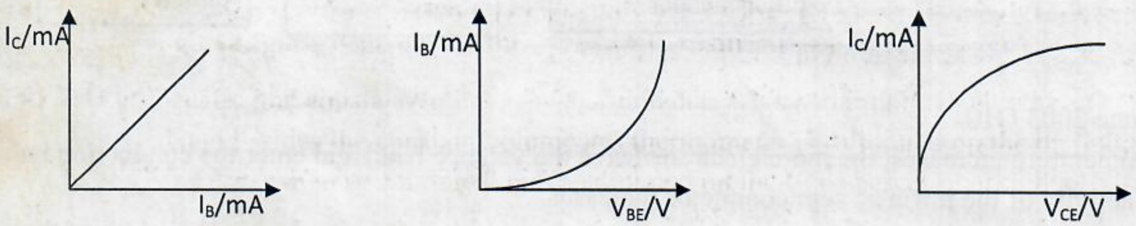
Therefore work done = 0.25x35 =8.75 J

4.(i) Electrical energy supplied, W = IVt = 1.5x240x60 =21600 J

$0.75 \times 21600 = mc\Delta\theta \Rightarrow m = \frac{16200}{c\Delta\theta} \Rightarrow m = \frac{16200}{460 \times 20} = 1.7$ kg

(ii) Assumption: Mass of the piece of iron is constant

5.



Transfer Input Output

(b) The current gain of the amplifier is slope of the transfer characteristic curve.

6.(i) Critical angle is the angle of incidence in the dense medium for which the angle of refraction in the less dense medium is 90^0.

(ii) $n_1 > n_2$ to enable total internal reflection occur at the core cladding boundary.

(iii) Considering figure 3, $n_1 \sin\theta_c = n_2 \sin 90° \Rightarrow \sin\theta_c = \frac{n_2}{n_1}$. Assuming light leaves glass into air, the critical angle for glass is given by $\sin C = \frac{n_a}{n_g} \Rightarrow C = \sin^{-1}\left(\frac{1}{1.5}\right) = 42°$

7.(i) This is because the constant volume gas thermometer is a standard on which other thermometers are calibrated and besides the constant volume gas thermometer is calibrated on the thermodynamic scale while the mercury in glass thermometer is calibrated on the Celsius scale. Since the Celsius scale is defined from the thermodynamic scale, it therefore implies both can give readings in degree Celsius. Note that a temperature rise of one Kelvin on the thermodynamic scale is equivalent to a temperature rise of one degree Celsius on the Celsius scale.

(ii) The variation of the length of the mercury thread with temperature is not the same as the variation of gas pressure with temperature.

8.(a) See your notebooks or textbooks.

b(i) Elastic collision means kinetic energy is conserved.

(ii) By the law of conservation of linear momentum,

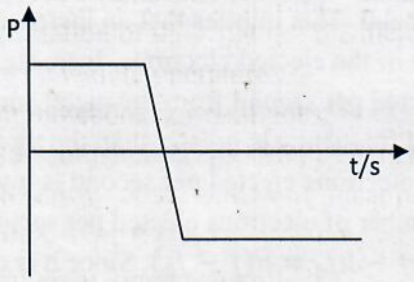
$mu_x = mv_x + mv_y \Rightarrow u_x = v_x + v_y$ .... (1)

Conservation of kinetic energy gives

$\frac{1}{2}mu_x^2 = \frac{1}{2}mv_x^2 + \frac{1}{2}mv_y^2 \Rightarrow u_x^2 = v_x^2 + v_y^2$ .... (2)

Solving (1) and (2) simultaneously, gives $v_x = 0$ *and* $v_y = 2.5\ ms^{-1}$. This means that X comes to rest and Y continues to move with the initial velocity of X. That is X transfers all it momentum and kinetic energy to Y as a result of the collision.

(iii) $F = \frac{\Delta P}{\Delta t} = m\left(\frac{v-u}{t}\right) = 0.4\left(\frac{0-2.5}{60\times10^{-6}}\right) = -1.67\times10^4\ N$. Thus the average force $=1.67\times10^4\ N$



(d) See your textbooks

(e) Seee June 2005 Q9

9.(a) (i) To be radioactive means the substance is capable of spontaneously and randomly emitting radiation. This can be as a result of low binding energy per nucleon.

(ii) **The use of cloud chambers:** In a cloud chamber, alpha tracks are thick and straight while beta tracks are thin and crooked.

The use of electric field: In a uniform electric field, alpha particles are deflected toward the positive plate while beta particles are deflected toward the positive plate

b(i) See your notes

$$\ln A = \ln A_0 - \lambda t \Rightarrow \ln A = -\lambda t + \ln A_0, \text{slope} = -\lambda \Rightarrow -\lambda = \frac{7.0-5.0}{(0-6.4)60} = \frac{-2}{384} \Rightarrow \lambda = \frac{2}{384}\text{s}^{-1}$$

But $T_{1/2} = \frac{ln2}{\lambda} = \frac{384\ln2}{2} = 133.08\ \text{s} = 2.22\ \text{min}$

(ii) $lnA_0 = 7 \Rightarrow A_0 = e^7 = 1.1\times10^3\ \text{min}^{-1}$

(d) A capacitor is a device used to store charge

(iia) Both diode and capacitor allows d.c to flow through them

(iib) A capacitor allows only a.c to flow through it whereas a diode allows both a.c and d.c in one direction only.

e(i) Consult your notebook

(ii) Initial charge, Q_0 = area under graph

Area of one square = $50\text{x}10^{-3}$ = 0.5 C

Total number of squares under the graph = 25.5

$Q_0 = 25.5 \times 0.5 = 12.75$ C

$Q = CV \Rightarrow C = \frac{Q}{V} = \frac{12.75}{10} = 1.275$ F

(iii) Time constant, $\tau = RC = 1.275 \times 100 = 127.5s$

10. (a) (i) Wave speed is the distance travelled by wave energy per unit time.

(ii) Displacement of a wave is the distance travelled by wave energy in a particular direction.

(b) See June 2002 Q10

(c) $x = \frac{\lambda D}{d}$ .Fringe separation, $x = \frac{12.5}{10} = 1.25\ mm \Rightarrow \lambda = \frac{xd}{D} = \frac{1.25\times10^{-3}\times0.05\times10^{-3}}{1.0} = 6.25 \times 10^{-7}$m

(d) (i)For electrons to be emitted from the surface of a metal, the frequency of the incident radiation must be greater than the threshold frequency of the metal. If electrons are emitted with uv light it means the the frequency of uv is greater than the threshold frequency of the metal, whereas for visible light, the frequency is less than the threshold frequency. That is why electrons are not emitted with visible light.

(ii) The work function for zinc is greater than that of potassium. Hence the maximum kinetic energy of electrons ejected from the surface of zinc will be greater than that for those ejected from the surface of potassium.

(e)(iii) The number of electrons ejected per second is proportional to the intensity of the incident radiation. A single can only eject a single electron. This happens when the frequency of the incident radiation is greater than the threshold frequency of the metal. This implies that an increase in frequency will result to an increase in the maximum kinetic energy of the ejected electrons. Increase in intensity only result to an increase in the number of electrons ejected per second from the metal surface. We observe that electrons are only ejected when the incident frequency is greater than the threshold frequency, kinetic energy is frequency dependent while electrons ejected per second is intensity dependent. Hence doubling the intensity doubles the number of electrons ejected per second

(iv) From the Einstein photoelectric equation, $E_{max} = hf - hf_0 = h(f - f_0)$. Since h is constant, it therefore implies that $E_{max} \propto (f - f_0)$

(v) Gamma photons have a shorter wavelength than infrared; hence they carry much energy than infrared radiation. Due to the shorter wavelength, they have a high penetration power than infrared and as a result cause more destruction.

(iv) $\Delta E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{\Delta E} = \frac{6.67\times10^{-34}\times3.0\times10^{8}}{(-1.5-13.6)1.6\times10^{-19}} = 1.0 \times 10^{-7}\text{m} = 100\text{ nm}$