JUNE 2010

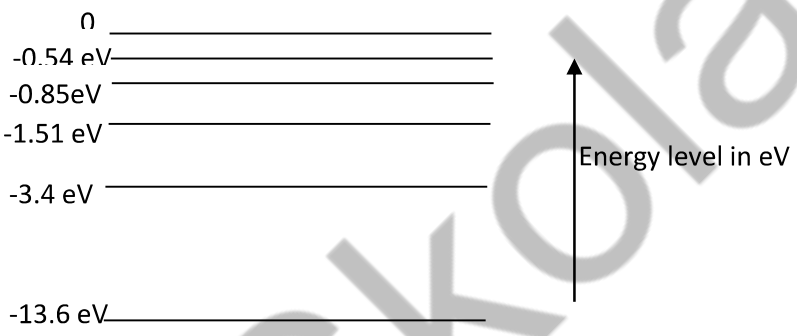
1. The force per unit length, F, between two wires placed a distance, r, apart in a vacuum and varying current, I_1 and I_2 in the same direction is given by $F = \frac{\mu_o I_1 I_2}{2\pi r}$ where μ_o is the permeability of a vacuum. Show that the equation is homogeneous.
2. (a) When two semiconductor materials, A and B, are doped using pentavalent and trivalent materials respectively and the two materials fused together, a p – n junction or a junction diode is created due to the presence of the depletion layer.
   (i) What is the depletion layer and how is it formed?
   (ii) What is the barrier potential?
   (iii) The p – n junction is connected to a power source (battery). Sketch the current pd curve in the forward and reverse bias if it is a silicon diode.
3. 

Figure 1

   Figure 1 above shows an energy level diagram for a certain atom
   (i) What is meant by the ground state
   (ii) What is the ionization energy of this atom
   (iii) Determine the wavelengths λ_1 and λ_2 of the transitions from -3.4 eV and -1.5 eV to the ground state respectively.
4.

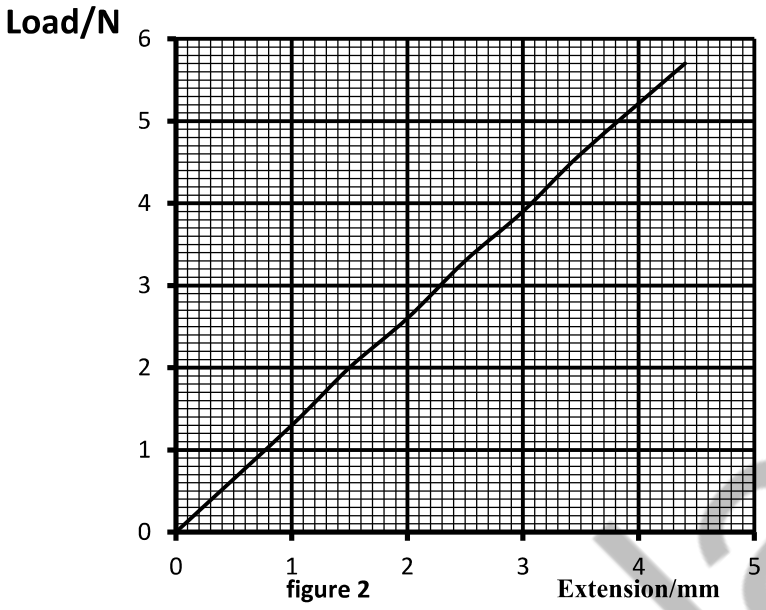


figure 2

Figure 2 shows some experimental results used to verify Hooke's law. The length of the wire is 2.0 m and its cross – sectional area is 0.10 m^2. Use the graph to

(a) Calculate the external work done on the wire in extending it by 4.0 cm

(b) Calculate the Young's modulus of the material of the wire

5. (a) How is the nuclide $^{238}_{92}U$ altered by:

(i) The emission of one alpha particle (ii) the emission of one beta particle

(iii) The absorption of one neutron

(b) Calculate the energy released when 5 kg of $^{238}_{92}U$ undergoes a fission according to the equation

$$^{238}_{92}U + {}^{1}_{0}n \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3{}^{1}_{0}n$$

Mass of $^{238}_{92}U$ = 235.04 U, $^{141}_{56}Ba$ = 140.997 U, $^{92}_{36}Kr$ = 91091 U, $3{}^{1}_{0}n$ = 1.01 U, 1U = 931 MeV

N_a = 6.02 x 10^{23} mol^{-1}.

6. A beam of parallel light is incident normally on a diffraction grating having 550 lines per mm. A telescope is used to observe the second order in the spectrum. Calculate the angular separation in radians of two spectral lines of wavelength 559 nm and 563 nm.

7. A faulty vehicle stands on a horizontal road. The vehicle is towed by means of a rope connected to another vehicle. Draw a free body diagram showing the horizontal forces acting on

(a) The vehicle being towed (b) The vehicle doing the towing

Identify the Newton Third law pair of forces

8. (a) (i) Define capacitance. State the factors that determine the capacitance of a parallel plate capacitor

(ii) Describe an experiment to measure the permittivity of air. Your description should include a diagram, procedure, precautions, observations, calculations and conclusion.

(b) (i) Calculate the escape velocity from the moon's surface given that the radius of the moon is 1738 km.

(ii) Calculate and comment about the electrostatic and gravitational force between an electron and a proton in an atom.

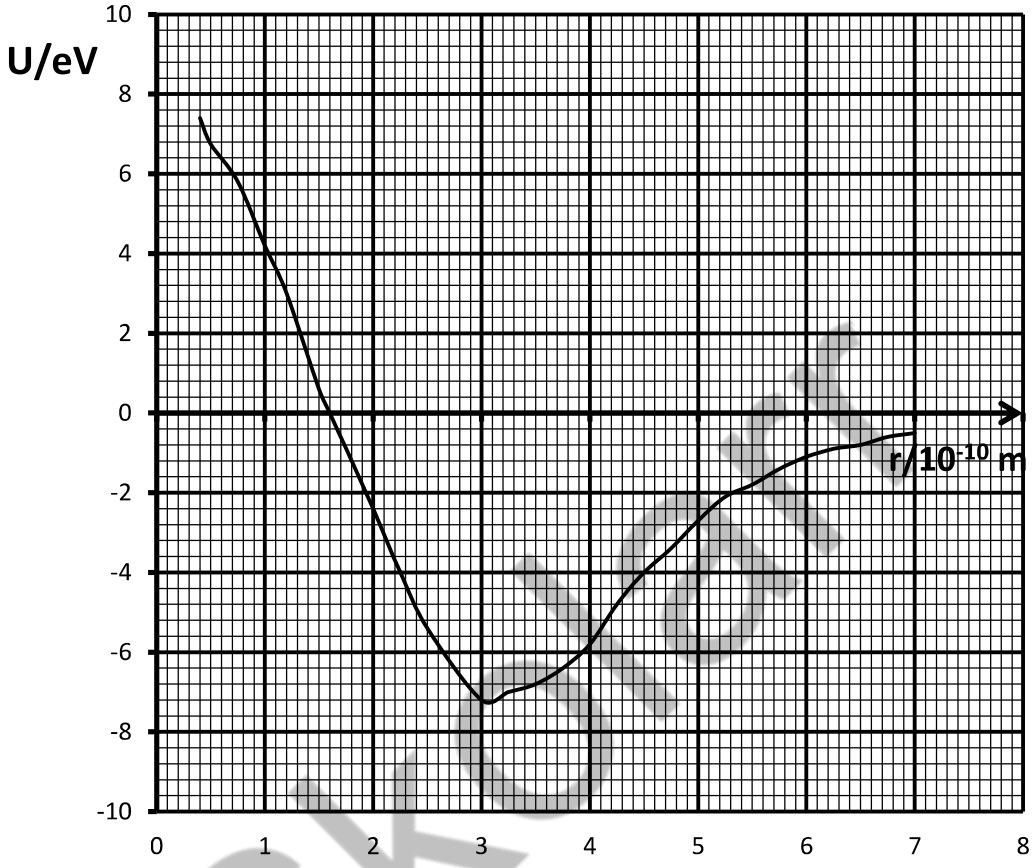
(c) (i) Define surface tension in terms of force. Show that the work done per unit area in changing the area of a liquid surface under isothermal conditions is equivalent to the definition of surface tension in terms of force.

(ii) Describe an experiment to show that surface tension of a liquid varies with temperature. Your account should include a diagram, procedure, observations, precautions, calculations and conclusions.

(c) When a jet of steam is sent into a container having 1.8×10^3 kg of ice at 0^0C, the ice turns into water at 5^0C. Find the smallest mass of steam that this requires if steam initially at 100^0C ends up as water at 5^0C. State any assumptions in your calculations.

9. (a) (i) What is meant by modulus of elasticity and elastic limit.

(ii) Explain how strength differs from stiffness of a given material.



(b) Figure 3 shows how the potential, U, between two neutral atoms varies with their distance apart.
(i) What is the minimum potential energy in joules?
(ii) With reference to the graph, explain the expansion of solids
(iii) Determine slopes at the points where the r values are 11 nm, 38 nm and 67 nm.
(iv) Plot a graph of slopes above against r, estimate the energy needed to separate the atoms completely.
(c) Explain how electromotive force is different from potential difference.

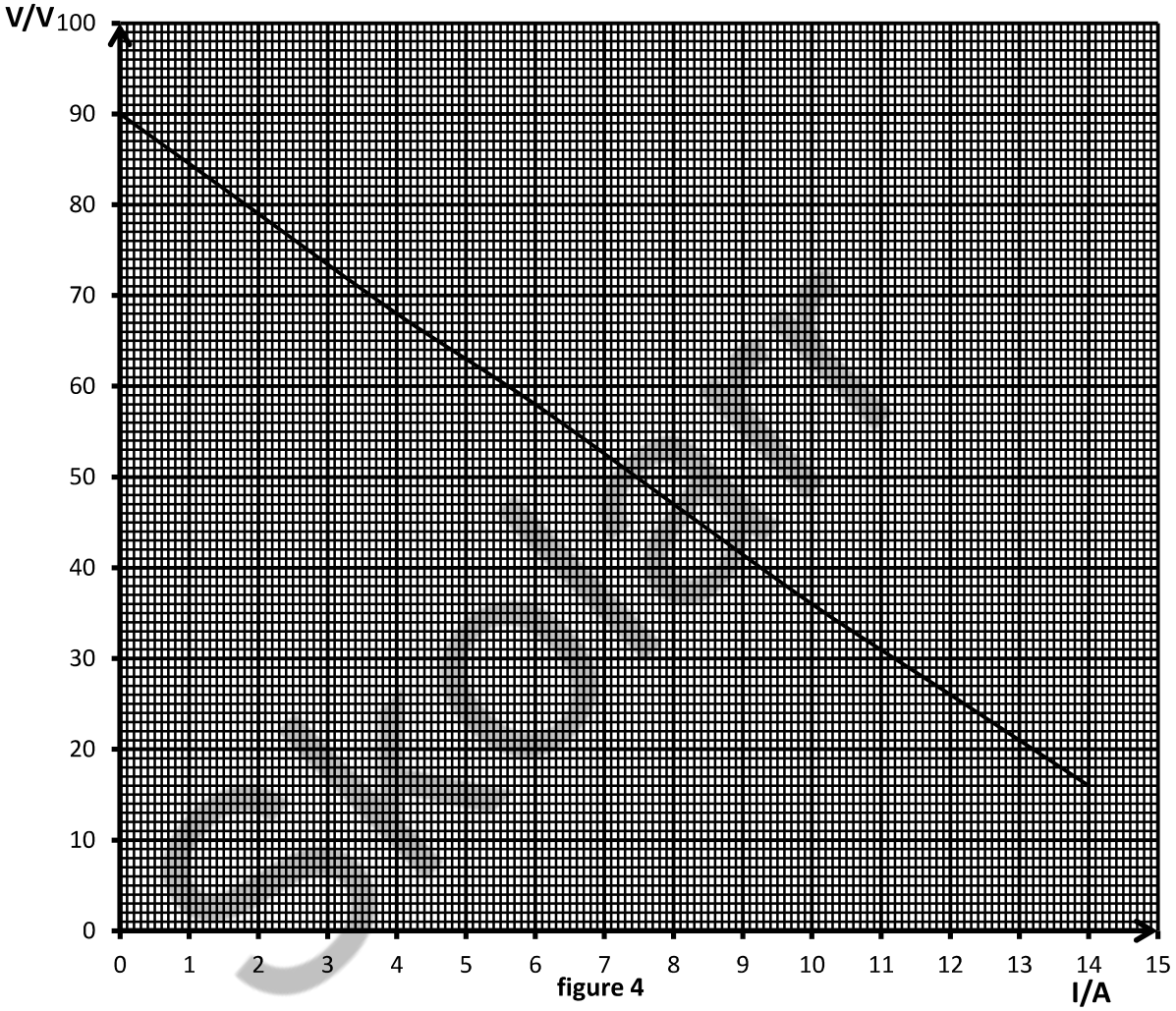


figure 4

Figure 4 shows the way V, across a resistor varies with the current, I, through it.

(i) Sketch a possible circuit diagram from which such results were obtained. Briefly explain the set – up.

(ii) From the graph in figure 4, determine the values for the emf and internal resistance of the cell.

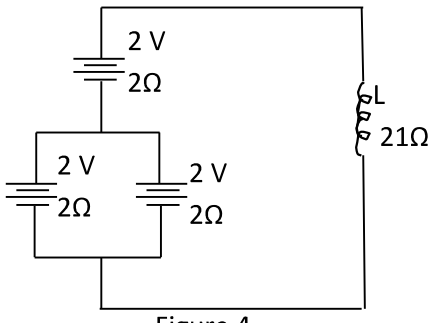


Figure 4

Figure 4 shows three identical batteries each of internal resistance 2Ω and emf 2 V. Calculate the current and voltage of the device L

10. (a) Distinguish between progressive waves and stationary waves in terms of energy, amplitude and phase of vibrations.

(b) A beam of light is incident at an angle of 56^0 on a glass and the reflected light is completely plane polarized.

(i) Explain what is meant by plane polarized beam?

(ii) Calculate the angle of refraction for the transmitted beam.

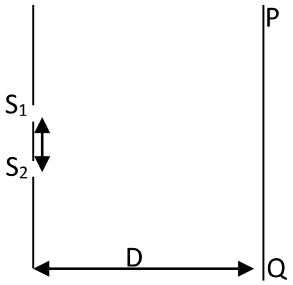


Figure 6

Figure 6 shows an arrangement which in practice enables an interference pattern to be observed.

(i) What are the conditions necessary for an interference pattern to be observed?

(ii) Explain how S_1 and S_2 become sources of waves.

(iii) What are the approximate dimensions for D and d in a laboratory condition when used to determine the wavelength of visible light?

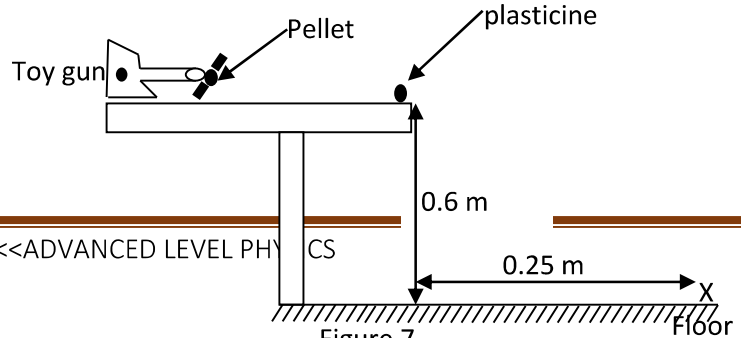
(iv) What could be observed along PQ if S_1 and S_2 are illuminated by white light?

(d) (i) Distinguish clearly between elastic and inelastic collisions

(ii) What is meant by the term linear momentum?

(iii) State the law of conservation of linear momentum and explain how force is related to linear momentum.

(e) A vehicle collides with a rain gate barrier when travelling at 27.7 ms^{-1} and is brought to rest in 0.075 s. If the mass of the vehicle and its occupants is 1000 kg, calculate the average force on the vehicle. The driver used his seat belt which restricted his movement through a distance of 0.25 m relative to the vehicle. What was the average force exerted by the belt on the driver if the driver's mass is 100 kg.



(f) Figure 7 shows a set up designed by a student to determine the velocity of a pellet from a toy gun. A piece of plasticine of mass 50 kg is balanced at the edge of a table such that it fails to fall off. A pellet of mass 10 g is fired horizontally into the plasticine and remains embedded in it. As a result the plasticine reaches the floor a horizontal distance of 0.25 m away from the edge of the table.

i. What is the horizontal velocity of the plasticine given that the table surface is 0.6 m high?
ii. What is the velocity of the pellet just before it hits the plasticine?
iii. What is the velocity of the plasticiine just before impact with the floor at a horizontal distance of 0.25 m.

STUDENT'S PROPOSED ANSWERS TO JUNE 2010